

# LI-6252 CO<sub>2</sub> Analyzer

## INSTRUCTION MANUAL



**LI-COR**<sup>®</sup>

# **LI-6252 CO<sub>2</sub> Analyzer**

## **Operating and Service Manual**



**Publication Number 9003-60**  
**March, 1996**  
**Software Version 2.02**

**LI-COR, inc.**  
**P.O. Box 4425**  
**4421 Superior Street**  
**Lincoln, Nebraska 68504**  
**Phone: (402) 467-3576**  
**FAX: (402) 467-2819**  
**Toll-free 1-800-447-3576 (U.S. & Canada)**

**U.S. and Foreign Patents Pending**

**Federal Communications Commission**  
**Radio Frequency Interference Statement**

This instrument generates and uses radio frequency energy and if not installed and used properly, that is, in strict accordance with these instructions, may cause interference to radio and television reception. This equipment is required to comply with the limits for a Class 'A' computing device pursuant to Subpart J of Part 15 of the FCC rules. A Class 'B' device is designed to be used in a residential area. Class 'A' specifications are designed to provide reasonable protection against such interference in a commercial environment. This equipment has been type tested and found to comply with the limits for Class 'A' computing devices, and is verified in accordance with FCC Part 15 Subpart J for the Class 'B' limits for a computing device. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception that can be determined by turning the instrument off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

1. Reorient the receiving antenna.
2. Relocate the instrument with respect to the receiver.
3. Plug the instrument into a different outlet (if so equipped) so that the instrument and receiver are on different branch circuits.

If necessary, the user should consult LI-COR or an experienced radio/television technician for additional suggestions.

The Federal Communications Commission has prepared a booklet entitled "How to Identify and Resolve Radio-Television Interference Problems" which may be helpful to you. This booklet (stock # 004-000-00345-4) is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

## **NOTICE**

The information contained in this document is subject to change without notice.

LI-COR MAKES NO WARRANTY OF ANY KIND WITH REGARD TO THIS MATERIAL, INCLUDING, BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. LI-COR shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

This document contains proprietary information which is protected by copyright. All rights are reserved. No part of this document may be photocopied, reproduced, or translated to another language without prior written consent of LI-COR, Inc.

© Copyright 1990, LI-COR, Inc.

---

IBM is a registered trademark of International Business Machines Corp.

PC-TALK is a trademark of Freeware.

ProComm is a trademark of Data Storm Technologies.

## **Printing History**

New editions of this manual will incorporate all material since the previous editions. Update packages may be used between editions which contain replacement and additional pages to be merged into the manual by the user.

The manual printing date indicates its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates which are incorporated at reprint do not cause the date to change).

1st Printing - April, 1990

2nd Printing - September, 1992

3rd Printing - March, 1996

# Table Of Contents

---

## Section I. Unpacking and Inspection

---

1.1 What's What .....	1-1
1.2 Checking the Batteries .....	1-3

---

## Section II. Setup and Operation

---

2.1 Setup and Operation .....	2-1
2.2 Power On .....	2-3
2.3 Absolute vs. Differential Mode Operation .....	2-4

---

## Section III. Theory of Operation: CO<sub>2</sub>

---

3.1 General Description .....	3-1
3.2 Calculating Gas Concentration - General .....	3-3
3.3 Calculating CO <sub>2</sub> Concentration .....	3-6
3.4 C <sub>r</sub> is Unknown. Measuring C <sub>r</sub> Against C <sub>s</sub> = 0 .....	3-7

---

## Section IV. Calibration

---

4.1 Calibration - General Information .....	4-1
4.2 Differential Mode Calibration .....	4-2
4.3 Absolute Mode Calibration .....	4-3
4.4 Pressure Corrections .....	4-3
4.5 Setting the Zero and Span in Software .....	4-4
4.6 Using the LI-670 Flow Control Unit .....	4-6

---

## Section V. System Software

---

5.1 Using the Keypad .....	5-1
5.2 Software Overview .....	5-2
5.3 Console Commands .....	5-3

---

## Section VI. H<sub>2</sub>O Corrections (Optional)

---

6.1 General Information .....	6-1
6.2 Pressure Broadening Due to Water Vapor.....	6-1
6.3 Dilution Corrections .....	6-5
6.4 Calculating H <sub>2</sub> O Concentration .....	6-7
6.5 Analog Inputs.....	6-9
6.6 Software Configuration .....	6-10

---

## Section VII. Interfacing

---

7.1 General Information .....	7-1
7.2 RS-232C Data Transfer .....	7-2
7.3 Analog Output .....	7-7
7.4 Auxiliary Channel Inputs.....	7-13
7.5 Temperature Output.....	7-14
7.6 Using the 6262-03 Pressure Transducer.....	7-15

---

## Section VIII. Maintenance

---

8.1 Recharging the 6000B and 6200B Batteries .....	8-1
8.2 Opening the LI-6252 .....	8-1
8.3 Internal Soda Lime/Desiccant .....	8-2
8.4 External Soda Lime .....	8-4
8.5 Internal Air Filters (Balston) .....	8-6
8.6 Fan Filter .....	8-7
8.7 Fuses .....	8-7

---

## Section IX. Troubleshooting

---

<b>APPENDIX A. Specifications</b>
<b>APPENDIX B. List of Suppliers</b>
<b>APPENDIX C. Software Command Index</b>
<b>APPENDIX D. Channel Code Headers</b>
<b>APPENDIX E. LI-6252 Console Commands</b>
<b>APPENDIX F. Connector Descriptions</b>
<b>APPENDIX G. Sample Program</b>
<b>Warranty</b>



# 1 Unpacking & Inspection

## 1.1 What's What

This procedure should be followed if you have just taken delivery on your LI-6252. Check the packing list to verify that you have received everything that was ordered and that you have also received the following items:

- **Calibration Sheet** - This data sheet contains a copy of the calibration information which was entered into the analyzer at the factory. Keep it in a safe place for future reference, or in case calibration data must be re-entered.
- **Console Command Sheet** - A quick reference card for entering console commands via the LI-6252 keypad or from an external terminal.
- **Spare Parts Kit** - This kit contains replacement parts for your LI-6252. As you become familiar with the analyzer you will learn which items to keep close at hand and which items can be stored away.
- **External Scrubber Tube** - This tube is used during normal operation. Several spare gaskets and adhesive disks are included for future use.
- **1000-90 Data Communications and Utility Software** - This software can be used to communicate with an IBM PC/XT/AT/PS2 or compatible. The software is provided on 3 1/2 inch diskettes.
- **RS-232C Cable** - (Part #392-02874) DTE to DCE, used to connect the LI-6252 (DCE) to a DTE device such as an RS-232C printer.
- **RS-232C Gender Changer** - (Part #392-02977) Female-to-female gender changer, used to connect the RS-232C cable to most computers.

## Section 1

---

There are several optional accessories available for use with the LI-6252, including:

**6262-03 Pressure Transducer** - measures pressure in the sample optical cell and its millivolt signal is used by the LI-6252 analyzer software to calculate pressure values. CO<sub>2</sub> readings are then automatically corrected by the software for any detected pressure changes.

**6000B Rechargeable Battery** (provides 3.2 hours of battery life).

**6200B Rechargeable Battery** (provides 6.4 hours of battery life).

**LI-6020 Battery Charger** (92-138/184-276 VAC, 47 to 63 Hz).

**1800-04 RS-232C Cable** - Used to connect the LI-6252 (DCE) to a standard IBM AT-type 9-pin RS-232C communications port.

In addition, LI-COR manufactures a portable dew point generator (LI-610), and a flow control unit (LI-670), which are valuable accessories for calibrating and operating the LI-6252.

### **LI-610 Portable Dew Point Generator**

The LI-610 is a precision instrument that provides a controlled water vapor source of known dew point. The LI-610 has the ability to generate stable dew points from 0 to 50 °C with high accuracy ( $\pm 0.2$  °C). The water vapor source can be derived from any input air stream, including ambient air, eliminating the need for external tanks or mixing of gases.

The dew point temperature of the air stream can be viewed on the LI-610's 4 1/2 digit LCD display, or output to the LI-6252 directly, as an analog signal, to be used in the water correction equations. Analog output is linear, and the 0-50 °C dew point range is scaled over 0-5 volts (100mV/°C).

The LI-610 can also be used to provide a known water vapor source for use in environmentally controlled measurement chambers.

### LI-670 Flow Control Unit

The LI-670 is a valuable accessory for use with the LI-6252, which can be used for a variety of calibration and gas exchange measurement functions. In its simplest form, the LI-670 is used as a constant source of air flow to the LI-6252. Independent pumps and rotameters allow variable flow rates through the LI-6252 sample and reference cells, if desired.

For calibration of the LI-6252, soda lime and desiccant tubes provide a zero gas source; a span gas can be swapped between cells to adjust for any zero offset present during calibration.

The LI-670 also can be used as a power source for the LI-6252; a built-in low battery detection circuit monitors battery life of the system. Mounting brackets are included for attaching the LI-670 and LI-6252, making the system completely portable.

## 1.2 Checking the Batteries (If purchased)

Batteries are tested and fully charged when they leave the factory, but they may discharge during shipping. It is a good idea to test each battery to see if it is charged. If the batteries are below 12V, they should be charged before use. Refer to Section 8.1 for charging instructions.

**NOTE:** *Never* store batteries in a discharged state. Charge stored batteries every 3 months.



# 2

## Setup & Operation

---

This section will describe the steps necessary for you to set up the hardware and software in your LI-6252 to begin making measurements. Follow these steps to configure your analyzer; where noted, the steps are described in more detail in this and other sections.

### 2.1 Setup and Operation

1. Prepare a soda lime tube as described in Section 8.4, and attach to the **SCRUBBER** holder on the back panel.
2. Absolute or Differential mode operation?

The LI-6252 can be operated in absolute or differential mode. In *absolute* mode, the reference cell contains a zero concentration of CO<sub>2</sub>. The sample cell is connected to the unknown gas to be measured. The signal from the sample cell is compared to the zero gas reference signal to provide absolute measurements of CO<sub>2</sub>. In *differential* mode, the reference cell contains a non-zero gas of **known concentration**. The difference between absorption in the sample cell and absorption in the reference cell is measured. Configuring the LI-6252 for differential or absolute mode operation requires slightly different hose connections; see Section 2.3, *Absolute vs. Differential Mode Operation*.

3. Turn the power ON.

The LI-6252 can be operated with AC or DC power. See Section 2.2, *Power On*.

4. Calibrate the analyzer as described in Section 4.
5. Connect sample airstream to be measured.

## Section 2

---

### 6. Configure analyzer for data output.

Data can be obtained from the LI-6252 in several different ways; from the display, via RS-232C output, or from one of the analog output channels. See Section 7, *Interfacing*, for more information.

### 7. Configure the software.

All software commands are executed by pressing **FUNCTION** and then entering a two-digit function code. Some codes execute a function directly, while others access scrollable lists of options, or other functions. Items in lists can be selected by scrolling the list with the arrow keys and pressing **ENTER**.

- Enter the station barometric pressure. Press **FCT**, followed by **77**, and enter the barometric pressure, in kPa.

Pressure may also be input continuously using the 6262-03 Pressure Transducer from LI-COR, or through auxiliary channel 15 with an external pressure sensor, as described in section 7.4.

- Set the parameters for RS-232C output, if necessary. Press **FCT**, followed by **17**, and enter the data output parameters.
- Set the Print List (FCT 13).

Data from up to ten different channels may be sent to the RS-232C port at a specified interval. See Section 5, FCT 13.

- Set Auto Print (FCT 14).

Enter specified interval in seconds (0.1-3600) at which to transmit data (defined at FCT 13) to the RS-232C port. See Section 5, FCT 14.

- Set Auto Header (FCT 15).

The column header interval is the number of data lines which will be printed between column headers. See Section 5, FCT 15.

- Set the displays (FCT 91-99).

The LCD display has two lines, and each line can be configured to show any channel code 21-29 (CO<sub>2</sub>), 31-39 (H<sub>2</sub>O), or 41-47 (MISC). As many as nine two-line display configurations can be defined by the Set Displays routine. Each display is identified by a number 1 through 9, and can be viewed by pressing the appropriate number *without* pressing **FCT**. See Section 5, FCT 04.

8. Begin making measurements.

## 2.2 Power On

1. If a LI-COR rechargeable battery is being used, connect it to the 10.5-16VDC battery connector on the rear panel. The 6000B Rechargeable Battery will provide power for approximately 3.2 hours at 25 °C, or 2.4 hours at 40 °C. The 6200B Rechargeable Battery has twice the capacity of the 6000B. Instructions for recharging these batteries are given in Section 8.1.

One set of battery leads with a 3-pin plug is included in the spare parts kit for connection to a user-supplied battery (10.5 - 16VDC, 1.5 amp maximum current required) or other DC power supply.

If AC line voltage is being used, make sure the AC VOLTAGE selector on the back panel is set correctly (choose the 115 setting for 100-130VAC, or the 220 setting for 200-260VAC), and plug the line cord into the receptacle on the back panel.

2. Turn the power switch on the front panel ON. The fan will run, and after a few seconds, the chopper motor will come up to speed. The READY light on the front panel will come on after 1-3 minutes. (The higher the ambient temperature, the longer it takes). Any one of the following conditions will cause the READY light to fail:
  - Ambient temperature greater than about 55 °C.
  - Level of CO<sub>2</sub> is too high in the reference cell (greater than about 3000 ppm).
  - CO<sub>2</sub> or water vapor in the detector, caused by the internal soda lime/desiccant bottle being exhausted.

### Low Battery Voltage

**IMPORTANT:** The LI-6252 has no built-in circuitry for monitoring battery voltage. When battery voltage drops below approximately 10.5 volts, the analyzer will shut down, and data transmission will stop. It is therefore suggested that battery voltage be monitored regularly to avoid system shutdown.

You may wish to monitor battery voltage with an external voltmeter, or use a timer with an alarm to alert the user to possible system shutdown. If you intend to operate the LI-6252 with battery power for more than 3 hours with the 6000B (6 hours with the 6200B), it is recommended that a user-supplied battery with a larger storage capacity be connected using the battery leads included with the LI-6252, or that several batteries be used in parallel for longer operation.

Note that the LI-COR LI-670 Flow Control Unit *does* have a built-in battery voltage detection circuit that will provide low battery detection for both instruments, when used with the LI-6252.

### 2.3 Absolute vs. Differential Mode Operation

The LI-6252 may be operated in either absolute or differential modes to measure CO<sub>2</sub> in any units. The following discussion will help you to set up the analyzer to measure these outputs.

Prepare a soda lime tube, as described in Section 8.4, and attach to the **SCRUBBER** holder on the back panel.

#### Differential Mode Operation

- Attach the bottom hose from the scrubber tube assembly to the **FROM CHOPPER** fitting, and the other hose to the **TO CHOPPER** fitting (Figure 2-1).



Figure 2-1. Hose connections for operation in differential mode.

## Absolute Mode Operation

- Attach the bottom hose from the soda lime tube to the **FROM CHOPPER** fitting.
- Attach the top hose to the **REFERENCE IN** fitting.
- Attach a jumper hose between the **REFERENCE OUT** and **TO CHOPPER** fittings (Figure 2-2).



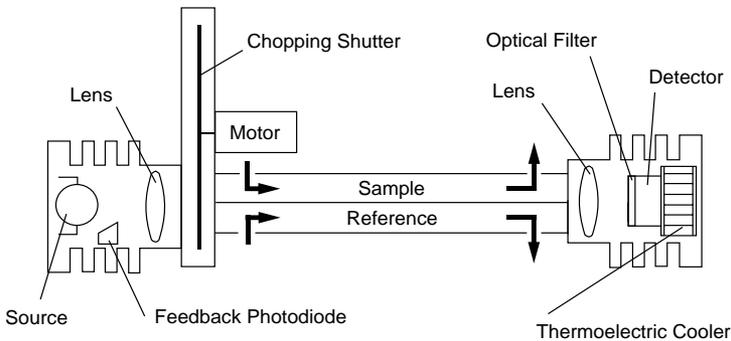
Figure 2-2. Hose connections for operation in absolute mode.



# 3 Theory of Operation

## 3.1 General Description

The LI-6252 is a differential, non-dispersive, infrared (NDIR) gas analyzer. The CO<sub>2</sub> measurements are based on the difference in absorption of infrared (IR) radiation passing through two gas sampling cells. The **reference cell** is used for a gas of known CO<sub>2</sub> concentration, and the **sample** cell is used for a gas of unknown concentration. Infrared radiation is transmitted through both cell paths, and the output of the analyzer is proportional to the difference in absorption between the two.



The infrared **source** is vacuum sealed for long life (> 10,000 hours) and high stability. A separate optical feedback circuit with a photodiode maintains the source at a constant color temperature (1250 °K). A gold reflector surrounding the IR source maximizes the radiation output from the source and decreases the power required.

The **chopping shutter** disc is spun by a motor, whose shaft turns on high precision bearings for long life and low noise. Rotation is precisely controlled at 500 hertz on a phase locked loop circuit. The optical path between the source and optical bench is sealed and continuously purged of CO<sub>2</sub> by an attached tube that contains soda lime. This eliminates interference due to ambient CO<sub>2</sub>.

## Section 3

---

The **sample cell** is gold-plated to enhance IR reflection and resist tarnishing over time.

A 150 nm bandpass optical **filter** is used to tune the CO<sub>2</sub> detector to the 4.26 micron absorption band for CO<sub>2</sub>. It provides excellent rejection of IR radiation outside the desired band, allowing the analyzer to reject the response of other IR absorbing gases. The filter is mounted directly to the detector for thermal stability.

The **detector** is a lead selenide solid state device that is insensitive to vibration. The detector is cooled and regulated to -12 °C by thermoelectric coolers, and electronic circuits continuously monitor and maintain a constant detector sensitivity. The result of this detector circuitry is a detector system that is very stable.

Infrared radiation from the source is focused through the gas cells and onto the detector by a lens at each end of the optical bench. Focusing the radiation maximizes the amount of radiation that reaches the detector in order to provide maximum signal sensitivity.

All of these features provide a noise level that is typically 0.2 ppm peak-to-peak (at 350 ppm) when using 1 second signal averaging, and 1 ppm peak-to-peak with 0.1 second signal averaging. Signal averaging times are selectable (in software) between 1 and 30 seconds and are used to achieve even lower noise levels. For example, with 4 seconds of signal averaging, the noise levels typically decrease 50%.

## 3.2 Calculating Gas Concentration - General

LI-COR gas analyzers use a lead selenide detector that operates approximately as a linear quantum counter; that is, over much of its range the detector signal output  $v$  is proportional to the number of photons reaching the detector. The output voltage  $V$  that is used to compute  $\text{CO}_2$  mole fraction is proportional to the difference between the signals generated by the detector when it sees the sample cell ( $v_s$ ) and when it sees the reference cell ( $v_r$ ).

$$V = k(v_r - v_s) \quad 3-1$$

The analyzer operates in such a way as to keep  $v_r$  constant, so we can factor  $v_r$  out of the quantity in parentheses, define  $K = kv_r$ , and obtain,

$$V = K \left( 1 - \frac{v_s}{v_r} \right) \quad 3-2a$$

In absolute mode, the instrument is operated with no  $\text{CO}_2$  in the reference cell so  $v_r$  is proportional to maximum photon throughput. The sample cell normally contains  $\text{CO}_2$ , which reduces the photon flux reaching the detector through the sample cell and reduces  $v_s$ . Therefore, the ratio  $v_s/v_r$  gives the ratio of photon flux in the presence of  $\text{CO}_2$  and in its absence, which is just the transmittance  $\tau$ . Since absorbance  $A$  equals  $1-\tau$ , we can also write equation 3-2 as

$$V = K(1 - \tau) \quad 3-2b$$

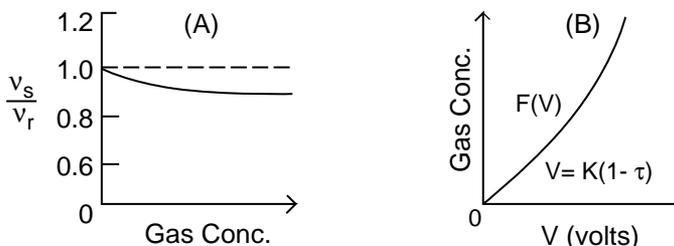
and

$$V = KA \quad 3-2c$$

The constant  $K$  is given on the calibration sheet.

Equation 3-2c indicates that the analyzer output voltage is proportional to absorbance; however, absorbance is a non-linear function of  $\text{CO}_2$  mole fraction. Absorbance and analyzer output voltage both increase with increasing  $\text{CO}_2$  mole fraction in the sample cell. Figure 3-1 illustrates a typical relationship between gas concentration, transmittance ( $v_s/v_r$ ) and analyzer output voltage.

## Section 3



**Figure 3-1.** (A) The ratio of detector output while viewing the sample cell ( $v_s$ ) and the reference cell ( $v_r$ ) decreases with increasing gas concentration. (B) The output voltage  $V$  is related to the ratio of  $v_s$  to  $v_r$  by Equation (3-2a). Gas concentration in terms of  $V$  is the calibration function  $F(V)$ .

The factory calibration of the analyzer consists of measuring the output  $V$  at several gas concentrations, and determining the coefficients for a fifth order polynomial  $F(V)$  that relates  $V$  to gas concentration, with a zero gas concentration in the reference cell.

$$F(V) = a_1V + a_2V^2 + a_3V^3 + a_4V^4 + a_5V^5 \quad 3-3$$

Coefficients  $a_1$  thru  $a_5$  are factory-determined for the specific gas, and are unique to each analyzer. *The calibration function  $F(V)$  is only valid for the temperature and pressure at which it was determined, and a zero gas concentration in the reference cell.* It has been found empirically that (absolute) temperature affects the gas concentration in a linear fashion, while pressure affects the signal output  $V$  in a linear fashion. Therefore, the expression relating signal output to gas concentration with a zero gas concentration in the reference cell (absolute mode) is

$$C = F\left(V \frac{P_0}{P}\right) \frac{T}{T_0} \quad 3-4$$

where  $P$  is barometric pressure in the cell (kPa),  $P_0$  is standard barometric pressure (101.3 kPa),  $T$  is IRGA temperature ( $^{\circ}\text{C}$  or  $^{\circ}\text{K}$ ), and  $T_0$  is IRGA calibration temperature ( $^{\circ}\text{C}$  or  $^{\circ}\text{K}$ ).

The situation is a little more complicated in differential mode. If we place a nonzero  $\text{CO}_2$  mole fraction in the reference cell, then infrared radiation will be absorbed, transmittance will decrease, and  $v_r$  should decline. This decline is prevented however, by an automatic gain control circuit that increases the detector gain by an amount necessary to hold  $v_r$  constant. This provides span stability over the long term, but the output voltage must now be

corrected for the gain increase before the calibration polynomial can be applied.

How much is this gain increase? The detector output signal  $v_r$  is proportional to photon flux, so to hold  $v_r$  constant, the gain must be inversely proportional to the reduced photon flux that results when  $\text{CO}_2$  is added to the reference cell. Transmittance is proportional to the photon flux, so *the gain increase is proportional to  $1/\tau_r$* , where the subscript r refers to the transmittance of the reference cell. Therefore, to correct for the gain increase, we find the transmittance of the reference cell given the reference cell  $\text{CO}_2$  mole fraction, and multiply the analyzer output voltage by  $\tau_r$ .

To find  $\tau_r$ , we assume that the sample and reference cells are optically identical when they contain the same absorbing gas concentrations. If the two cells are identical, then for a given gas concentration, the transmittance will be the same whether it is computed against zero between the cells or within either cell.

Now, suppose the reference cell contains  $\text{CO}_2$  mole fraction  $C_r$ . If we can compute what the transmittance would be if  $C_r$  were in the sample cell against zero in the reference cell, then we will know what the transmittance actually is in the reference cell when it contains  $C_r$ , and that will tell us how to correct for the gain change.

The strategy for accomplishing this is straightforward. First, we use  $C_r$  to solve equation 3-4 for  $V_r$ , giving

$$V_r = F^{-1} \left( C_r \left[ \frac{T_o}{T} \right] \right) \left( \frac{P}{P_o} \right) \quad 3-5$$

Then, rearrange equation 3-2b to find  $\tau_r$  given  $V_r$ ,

$$\tau_r = \left( 1 - \frac{V_r}{K} \right) \quad 3-6$$

Equations 3-5 and 3-6 ordinarily apply to the situation where  $C_r$  is in the sample cell and zero is in the reference cell; but if the cells are identical,  $\tau_r$  also computes the transmittance in the reference cell when  $C_r$  is present. The gain correction  $G$  equals  $\tau_r$ , as shown earlier, so

$$G = \left( 1 - \frac{V_r}{K} \right) \quad 3-7$$

## Section 3

---

After correcting the differential voltage  $V$  for the gain change we can write  $GV = V_s - V_r$ . Solving for  $V_s$  and substituting the result into equation 3-4 gives the general expression for computing the gas concentration  $C$  in the sample cell given concentration  $C_r$  in the reference cell,

$$C = F \left[ (VG + V_r) \frac{P_o}{P} \right] \left[ \frac{T}{T_o} \right] \quad 3-8$$

The differential  $\text{CO}_2$  mole fraction  $\Delta C$  is simply  $(C - C_r)$ .

$$\Delta C = F \left[ (VG + V_r) \frac{P_o}{P} \right] \left[ \frac{T}{T_o} \right] - C_r \quad 3-9$$

In this section we have assumed that the sample and reference cells are optically identical. Strictly speaking, of course, that is not true. This can be illustrated by setting zero with zero gases in both the sample and reference cells and then placing a single span gas in both cells. A small zero offset will usually be observed, illustrating any minor optical differences between the cells that may exist. Nevertheless, the treatment given here works very well in practice. Small optical anomalies of whatever origin can be corrected empirically by setting zero and span.

### 3.3 Calculating $\text{CO}_2$ Concentration

Mole fraction  $\text{CO}_2$   $C$  ( $\mu\text{mol/mol}$ , displayed using FCT 22) comes directly from equation 3-8. The reference concentration value  $C_r$  ( $\mu\text{mol/mol}$ , entered via FCT 59) should reflect the effects of dilution by water vapor, if it is not dry. See sections 6.2 and 6.3.

$\text{CO}_2$  differential  $\Delta C$ , ( $\mu\text{mol/mol}$  (FCT 23) is  $C - C_r$ .

$\text{CO}_2$  partial pressure  $p_c$  (Pa, displayed using FCT 24) is computed from  $C$  and total pressure  $P$  (kPa) by

$$p_c = \frac{cP}{1000} \quad 3-10$$

The  $\text{CO}_2$  weight fraction  $c_g$  ( $\mu\text{g/g}$ , displayed at FCT 26) is computed as

$$C_{\text{g}} = \frac{44c}{M} \quad 3-11$$

where  $M$  = molecular weight of air (g/mol), weighted for water vapor.  
 $= 29(1 - w/1000) + 18w/1000$   
 $w$  = mole fraction of water vapor (mmol/mol).

### 3.4 $C_r$ is Unknown. Measuring $C_r$ against $C_s = 0$

Sometimes a  $\text{CO}_2$  differential must be measured when the reference  $\text{CO}_2$  mole fraction is not precisely known. For example, one might be measuring photosynthesis in the field with ambient air as the reference gas, the exact  $\text{CO}_2$  mole fraction of which is not known. One could scrub the reference cell and measure the incoming  $\text{CO}_2$  concentration in absolute mode. However, there will be a small zero shift when the reference gas is reduced from around 350 ppm to 0 ppm, so a zero adjustment must be made each time the reference cell is scrubbed. The same is true when ambient air is returned to the reference cell.

It is easier to leave the reference gas alone and scrub the sample cell; this avoids zero shifts and gain changes. One can then measure  $V_c$  and compute  $V_r$  and  $C_r$  according to equations 3-12 and 3-13.

$$V_r = \frac{-V}{1 - \frac{V}{K}} \quad 3-12$$

$$C_r = F \left[ V_r \frac{P_o}{P} \right] \left( \frac{T + 273}{T_o + 273} \right) \quad 3-13$$

These values can be used as needed to compute  $C_s$  or  $\Delta C$  over as long a time period as  $C_r$  and temperature are stable. **Note:** This is not implemented in the instrument, but is provided as an aid to those needing this trick.



# 4 User Calibration

## 4.1 Calibration - General Information

The factory calibration of the LI-6252 CO<sub>2</sub> Analyzer consists of determining the coefficients for the calibration polynomial for CO<sub>2</sub>. These coefficients should be quite stable over time, but we recommend that they be checked every two years by returning the LI-6252 to LI-COR for recalibration.

The user calibration consists of adjusting the zero and span potentiometers so that the analyzer's output matches the linearization polynomial  $F(V)$ . **This should be done on a daily basis (unless the 6262-03 Pressure Transducer is installed), as the span varies with barometric pressure, and the zero varies with temperature.**

Figure 4-1 illustrates the effects of the zero and span adjustments.

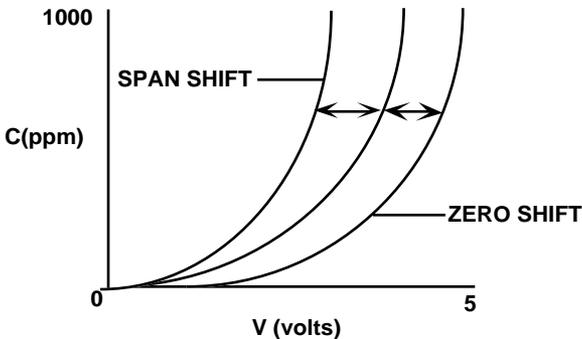


Figure 4-1. Effects of zero and span adjustments.

Procedures for zero and span calibrations are given in Section 4.2 for differential mode operation and in Section 4.3 for absolute mode operation.

### 4.2 Differential Mode Calibration

It is important to remember that in differential mode the pressures on the two sides of the analyzer must be kept the same. For this reason, never connect the exit ports (**SAMPLE OUT** and **REFERENCE OUT**) to anything - just vent them to the atmosphere, or to tubes of equal length. If you wish to flow the same gas through both sides of the analyzer, *try to avoid* doing it by putting the sample and reference cells in series, as you will likely have different pressures. Instead, split the flow upstream of the analyzer, and run separate hoses to the reference and sample cells. Also, be sure the flow rates through both sides are the same.

The concentrations used to set the zero and span should bracket the range of concentrations expected in subsequent measurements. For example, using 340 ppm for the zero and 300 ppm for the span might be the proper selections for flow-thru photosynthesis chamber applications, where draw-downs from ambient are expected.

There is generally a small zero shift when the reference concentration changes. Therefore, if operating in a mode in which there are significant changes in reference gas concentration, you should re-zero the analyzer following each change in concentration.

#### Zero and Span Calibration

1. Set the CO<sub>2</sub> reference to zero (FCT 59). If you are not using the 6262-03 Pressure Transducer, enter the barometric pressure in FCT 77.
2. Display absolute CO<sub>2</sub> μmol/mol (FCT 22).
3. Flow a dry CO<sub>2</sub>-free gas through both sides of the analyzer.
4. Unlock the CO<sub>2</sub> zero potentiometer and adjust until the absolute CO<sub>2</sub> concentration on the display reads zero.
5. With the CO<sub>2</sub>-free gas on the reference side, flow a span gas through the sample cell. Set the span potentiometer to read the span gas mole fraction (μmol/mol).
6. Flow the span gas through both cells of the analyzer at the same flow rate. The flow rate should match that used in the reference cell. Set the CO<sub>2</sub> reference (FCT 59) to the span gas mole fraction (μmol/mol). Display differential CO<sub>2</sub> (FCT 23).

7. There will likely be a small zero offset. Adjust the zero potentiometer to read zero.
8. To check the span, flow a different gas through the sample cell. FCT 22 should show that value. If you don't have a second gas, you could scrub the sample cell, and see if FCT 22 reads zero. Adjust the span as needed.
9. Lock the potentiometers.

### **4.3 Absolute Mode Calibration**

The procedure for setting the zero and span potentiometers in absolute mode is described in Steps 1 thru 5 above for differential mode calibration.

### **4.4 Pressure Corrections**

**NOTE:** This section may be disregarded if the 6262-03 Pressure Transducer is installed.

The LI-6252 is sensitive to pressure differences between the sample and reference cells. The span of the analyzer should be set with a span gas flow rate equal to the flow rate at which it will be used. With the flow of the analyzer vented to the atmosphere the effect is minimal, but if the flow from the analyzer must pass through tubing, fittings, etc., the pressure increase must be taken into account.

If it is not convenient or possible to have the span gas flow rate equal to the flow rate used during measurement, the pressure effect can be characterized, and the span set at zero flow, after complete purging of the sample cell. The procedure for this is as follows:

1. Connect a stable source of air to the input of the analyzer, and adjust the flow rate to be equal to the flow rate at which measurements will be taken.
2. Monitor CO<sub>2</sub> on the display, and record the concentration after the reading has stabilized.
3. Shut the flow off, leaving this same concentration in the sample cell.

## Section 4

---

- Record the concentration from the display.

$$\text{Correction factor} = \text{Conc. (with flow)} / \text{Conc. (without flow)}$$

When setting the span, multiply the reading obtained without flow by the correction factor, and set the displayed concentration equal to the corrected value.

This flow/concentration relationship is linear over the entire measurement range of the LI-6252. If another flow rate is used, a new correction will have to be calculated.

### 4.5 Setting the Zero and Span in Software

FCT 08 (Test Menu) contains a CO<sub>2</sub> Zero/Span function that provides a software method of setting the zero and span without manually adjusting the potentiometers. There are two advantages of allowing software zero and span adjustments; the zero and span can be set using a remote command sequence, and the user can get the analyzer back “on scale” through software if the zero and/or span has gone beyond the range of the potentiometer.

The zero and span parameters initially default to these values:

$$\text{C2 Zero} = 0.0 \text{ (mV offset)}$$

$$\text{C2 Span} = 1.0 \text{ (dimensionless)}$$

When these default values are in effect, no software zero or span adjustments are performed.

When the C2 Zero and C2 Span values are changed, the mV signal normally used in the calculation of CO<sub>2</sub> concentration (FCT 21) is transformed according to

$$\text{CO}_2 \text{ mV}_{\text{new}} = (\text{C2 Span}) \times (\text{mV} - [\text{C2 Zero}]).$$

The value of CO<sub>2</sub> mV<sub>new</sub> is used by the calibration polynomial to compute concentration, but does not change the raw CO<sub>2</sub> mV signal displayed at channel 21, or the output (RS-232C) values.

The values of C2 Zero and C2 Span can be entered via the keypad at FCT 08, or by sending a remote command sequence. When sending a remote command, you have the option of entering the C2 Zero and Span values, or allowing the analyzer software to calculate the values for you. The

following examples demonstrate how you can calibrate your LI-6252 in software for both absolute and differential measurements.

## Remote Command

The remote command sequence for the CO<sub>2</sub> software zero and span is

```
*081,C2 Zero,C2 Span,CO2 concentration (μmol/mol).
```

The CO<sub>2</sub> concentration is an optional parameter, and is used only when you want the software to compute the zero or span value. If the concentration is set to zero, the software computes the zero offset and stores it as C2 Zero. *When zero is entered, you must have the same gas concentration flowing to both the sample and reference cells of the analyzer.* If any value other than zero is entered, the software computes the dimensionless span value for that concentration as

$$\text{C2 Span} = V_{\text{calc}} / V_{\text{meas}} = F^{-1} (\text{C2 Span } T_o/T) / V_{\text{meas}}$$

**NOTE:** The LI-6252 will not accept remote commands while the Test Menu is active. Exit the Test Menu and enter display mode; the remote command will then be executed.

## Absolute Mode Calibration

1. Set the CO<sub>2</sub> zero.
  - Flow CO<sub>2</sub>-free air through the chopper housing, reference, and sample sides of the analyzer.
  - Send remote command \*081,0,1,0 to set the zero.
2. Set the CO<sub>2</sub> span. Let's assume that we are using a 500 ppm span gas.
  - Flow CO<sub>2</sub>-free air through the chopper housing and reference side of the analyzer.
  - Flow 500 ppm span gas through the sample side of the analyzer.
  - Send remote command \*081,0,1,500 to set the span.

## Differential Mode Calibration

Assume for this example that we are using precision span tanks of 300 and 500 ppm CO<sub>2</sub>.

1. Set the CO<sub>2</sub> zero.

## Section 4

---

- Flow CO<sub>2</sub>-free air through the chopper housing, and the 300 ppm gas through the reference and sample sides of the analyzer.
  - Send remote command \*081,0,1,0 to set the zero.
  - Set FCT 59 (CO<sub>2</sub> reference) to 300.
2. Set the CO<sub>2</sub> span.
- Flow CO<sub>2</sub>-free air through the chopper housing.
  - Flow 300 ppm span gas through the reference side of the analyzer.
  - Flow 500 ppm span gas through the sample side of the analyzer.
  - Send remote command \*081,0,1,500 to set the span.

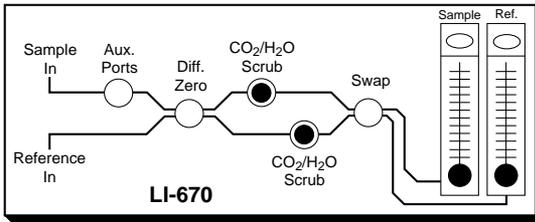
### 4.6 Using the LI-670 Flow Control Unit

The LI-670 Flow Control Unit can be a valuable accessory for operating and calibrating your LI-6252. The following discussion describes how you can calibrate your LI-6252 using the LI-670 and a single span gas.

#### Absolute and Differential Mode Calibration with One Span Gas.

##### **Absolute mode. Set zero.**

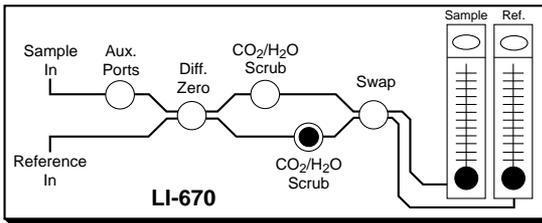
1. Connect the LI-6252 **Sample In** fitting to the LI-670 **Sample Out** fitting, and the LI-6252 **Reference In** fitting to the LI-670 **Reference Out** fitting.
2. Enter the station barometric pressure into the LI-6252 at FCT 77. Alternatively, you can use the 6262-03 Pressure Transducer, or an external sensor to input the barometric pressure.
3. Connect a span tank containing air (*not nitrogen*) with a known CO<sub>2</sub> mole fraction to the LI-670 **Sample In** and **Reference In** fittings, and turn both the reference and sample **CO<sub>2</sub>/H<sub>2</sub>O Scrub** switches ON. Use tank pressure to provide flow at a nominal rate near that used during measurements. Final flow rate adjustments can be made with the LI-670 **SAMPLE** and **REFERENCE** vents.
4. When the CO<sub>2</sub> reading is steady, adjust the zero potentiometer on the LI-6252 until the display reads zero.



*Scrub both cells.*

**Absolute mode. Set span.**

- Turn OFF the SAMPLE  $\text{CO}_2/\text{H}_2\text{O}$  Scrub switch. Leave the REFERENCE  $\text{CO}_2/\text{H}_2\text{O}$  Scrub switch ON. Adjust the flow as needed.
- Set the LI-6252 span when the displayed  $\text{CO}_2$  reading is steady.



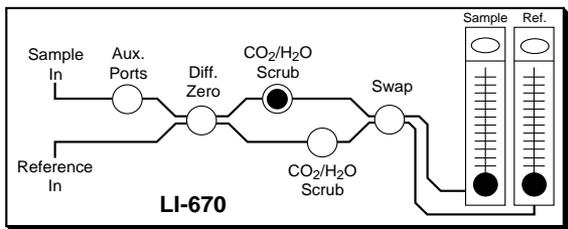
*Scrub only the reference cell.*

The LI-6252 is now ready for use in absolute mode. Differential mode operation requires three additional steps.

**Differential mode. Set zero.**

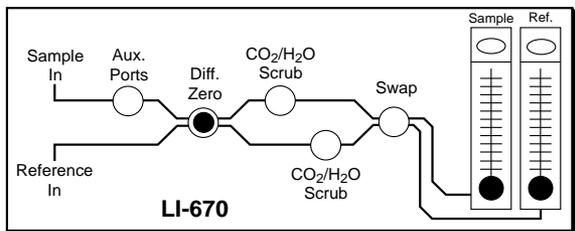
- Perform steps 1 through 6, and then turn OFF the REFERENCE  $\text{CO}_2/\text{H}_2\text{O}$  Scrub switch. Adjust the flow to near that which will be used during measurements.
- Adjust the LI-6252 to read zero when the displayed  $\text{CO}_2$  mole fraction is steady. Only a small adjustment should be necessary (about 5 ppm) when switching from zero to 350 ppm in the reference cell.
- Enter the span gas  $\text{CO}_2$  mole fraction in FCT 59 in the LI-COR analyzer. Read differential  $\text{CO}_2$  on the analyzer display. Check the span by scrubbing the sample cell and looking for zero on FCT 22.

## Section 4



*Scrub the sample cell.*

The LI-6252 zero or span can be checked during measurements by turning ON the **Diff Zero** switch, and then using whichever scrubbers are needed.



*Flow the span gas through both cells of the analyzer.*

Many other calibration variations are possible. For example, you may want to recirculate air in a closed reference loop for absolute mode operation.



# 5

## System Software

### 5.1 Using the Keypad

The LI-6252 uses a 16-key keypad for entering all software function commands and calibration data. The keys are arranged as in Figure 5-1, and function as follows:

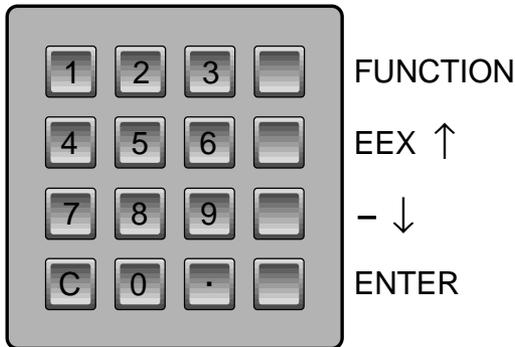


Figure 5-1. The LI-6252 Keypad.

**Numeric keys (0-9) and decimal key** - Used to enter software function codes and calibration numbers.

**Function key** - Function prompt is accessed, allows user to enter any software function command #00-99.

**Exponent/Scroll Up key** - Used to enter exponents (i.e., when entering CO<sub>2</sub> calibration numbers), or to scroll upward through option lists.

**Minus/Scroll Down key** - Used to enter a negative number sign, or to scroll downward through lists.

**Enter key** - Used to terminate user input from the keypad after entering numbers, or to select list entries.

**Clear key** C - Functions as a backspace key, deletes last character.

### 5.2 Software Overview

All software commands are executed by entering a two-digit function code following **FUNCTION**. Some codes execute a function directly, while others access scrollable lists of options, or other functions, any one of which can be selected by pressing **ENTER**.

All functions are contained in the main menu, by order of function code. Decade functions (00, 10, 20, ...90) merely serve as entry points to this menu. For example, pressing FCT 10 will access the menu at 10, from which point  $\uparrow$  or  $\downarrow$  can be used to scroll to neighboring functions. On the other hand, pressing FCT 11 does not access the menu, but executes function 11 directly. Rapid scrolling down through the menu is done by pressing **ENTER** while viewing a decade function; you will jump to the next decade function (e.g. from 10 to 20) in the menu.

To illustrate the use of the **FUNCTION** key and the main menu, try this:

1. Press FCT 90. The display will show the main menu at 90 as **\*\*DISP\*\***.
2. Press  $\downarrow$  to move down one entry to function 91.
3. Press **ENTER**. This will select function 91, which shows the channel code that is currently defined for the top line of display #1, and prompts for a new value.
4. Press **ENTER** to retain the displayed value. You are prompted to enter a channel code for the bottom line of display #1. Press **Enter** again to retain the displayed value. Note that the display has returned to the menu.
5. Press  $\uparrow$  to scroll up to function 90, **\*\*DISP\*\***.
6. Press **ENTER**. Selecting a decade function jumps to the next decade function, so the display will show 00, **\*\*SETUP\*\***.
7. Press **FUNCTION** to exit the menu.
8. Press FCT 91. This will execute the function described in step 3 above, which prompts for a new channel code for the top line of display #1.
9. Press **ENTER** to retain the displayed value of this constant, or press **FUNCTION** to cancel the operation.

## Remote Commands

Certain function codes can be sent to the LI-6252 from a computer or terminal, as shown on the console command card.



Section 7.2 gives a complete explanation of how to connect your computer and LI-6252 for data transfer and for sending remote commands. Look for the icon at left in the following section for examples of how to format entries to be sent to the LI-6252.

## 5.3 Console Commands

This section discusses each function in detail. It may be helpful to reference the console command reference card while reading through the definitions of the following functions.

### 00 Setup

```
00** SETUP **  
↑, ↓, ↵
```

Scroll ↑ (UP), ↓ (DOWN), or  
**ENTER** .

## 01 CO<sub>2</sub> Calibration

Function 01 is actually a group of functions; executing FCT 01 performs individual functions 51-59 and 76.

The LI-6252 is calibrated over a 0-3000  $\mu\text{mol/mol}$  range, using a 5th order calibration polynomial of the form  $\mu\text{mol/mol} = A(\text{mV}) + B(\text{mV})^2 + C(\text{mV})^3 + D(\text{mV})^4 + E(\text{mV})^5$ . The calibration coefficients (T,K,A,B,C,D,E) are entered into the LI-6252 at the factory, and are shown on the calibration sheet.

CO<sub>2</sub> reference ( $\mu\text{mol/mol}$ ) and the choice of water correction depend upon your system setup. See functions 59 and 76 for complete descriptions.

Check the calibration sheet to verify that the correct values are entered.

<u>Prompt</u>	<u>Description</u>	<u>Related Function</u>
C2 T=	Calibration Temperature	51
C2 K=	Calibration Constant K	52
C2 A=	Calibration Coefficient A	53
C2 B=	Calibration Coefficient B	54
C2 C=	Calibration Coefficient C	55
C2 D=	Calibration Coefficient D	56
C2 E=	Calibration Coefficient E	57
C2 R=	CO <sub>2</sub> Reference $\mu\text{mol/mol}$	59
Corrections Off	Water correction selection	76



\*01T,K,A,B,C,D,E,REF,VAPOR FLAG

## 02 H<sub>2</sub>O Calibration

See Section 6.6.

<u>Prompt</u>	<u>Description</u>	<u>Function</u>
H2 T=	Not used	61
H2 K=	See Section 6.4	62
H2 A=	See Section 6.4	63
H2 B=	See Section 6.4	64
H2 C=	See Section 6.4	65
H2 R=	See Section 6.4, Mole fraction H <sub>2</sub> O in reference cell	68

## 03 Set Miscellaneous

Function 03 performs functions 77 and 71-75.

<u>Prompt</u>	<u>Description</u>	<u>Function</u>
P(kPa)=	Barometric Pressure	77
Avg(s)=	Signal Averaging Time	74
Aux A=	Auxiliary input A (Offset) coefficient	71
Aux B=	Auxiliary input B (Multiplier) coefficient	72
Aux C=	Auxiliary input C coefficient	75
Aux Dest=	Auxiliary Destination	73

There is no remote command for FCT 03, but all of the 7x functions can be accessed remotely.

## 04 Set Displays

Function 04 performs functions 91-99.

The LCD display has two lines, and each line can be configured to show any channel code 21-29 (CO<sub>2</sub>), 31-39 (H<sub>2</sub>O), or 41-47 (MISC). As many as nine two-line display configurations can be defined by the SET DISPLAYS routine. Each display is identified by a number 1 through 9, and can be viewed by pressing the appropriate number *without* pressing **FCT**.

**NOTE:** Displays 1-3, & 6 (FCT 91-93, 96) default to the configurations shown below at initial power-up or system reset.

<u>Display</u>	<u>Function Codes (Top/Bottom Lines)</u>	<u>Description</u>
1	21	CO <sub>2</sub> mV (non-linear)
	22	CO <sub>2</sub> μmol/mol absolute
2	23	CO <sub>2</sub> μmol/mol differential
	29	CO <sub>2</sub> μmol/mol reference
3	41	Temperature mV
	42	Temperature °C
6	43	Barometric Pressure (kPa)
	44	Auxiliary mV

Set the displays as follows:

Press **FCT**, followed by 04. The display will show:

1 Top=21  
NEW= \_\_

Shows default channel code for top of display 1. Enter new code 21-29, 31-39, or 41-47.

1 Bottom=22  
NEW= \_\_

Default channel code for bottom of display 1.

Prompts to configure displays 2 through 9 follow. Press **FCT** to quit.

## 05 Set D/A Conversion #1

Function 05 performs functions 81-83.

DAC 1 Code=  
NEW= \_\_

Digital to analog conversion  
code #1.

Digital to Analog Conversions may be performed on channel codes 22-27, or 42. See function codes 80-83 for further details.



**\*05X,low,high** (where x is channel code 22-27, or 42).

## 06 Set D/A Conversion #2

Function 06 performs functions 84-86.

DAC 2 Code=  
NEW= \_\_

D/A Conversion #2 (same as  
05).



**\*06X,low,high** (where x is channel code 22-27, or 42).



**The A/D (Analog-to-Digital) Zero Test** displays the analog count of output channels 1 and 2. If the A/D converter is functioning properly, these values should be nearly identical (approximately 32,700).

**The A/D (Analog-to-Digital) Span Test** displays the analog count of output channels 1 and 2, as well as the analog count and actual mV output of the CO<sub>2</sub>, Temperature, and Auxiliary output channels.

**The RAM (Random Access Memory) Test** shows the amount of available system RAM. The LI-6252 has approximately 8K bytes of RAM.

**The EEPROM (Electrically Erasable Programmable Read-Only Memory) Test** shows the amount of available ROM memory. The system parameters entered by the user are stored in EEPROM. The LI-6252 has approximately 32K bytes of ROM program memory.

**Geopotential** - Displays the geopotential height in feet or meters, based on the current value of pressure at channel 43. This value can be provided by a sensor (FCT 73) or as a keyboard entered constant (FCT 77). Press the up or down arrow keys to toggle between units of feet and meters. Geopotential height is height above sea level in a standard atmosphere.

**The I/O (Input/Output) Test** checks the Input/Output capabilities of the RS-232C port. This test requires pins 2 and 3 to be shorted on the RS-232C connector.

**CO<sub>2</sub> Zero/Span** - Provides a method to set the CO<sub>2</sub> zero and span in software, via the keypad or by sending a remote command sequence. See Section 4.5, *Setting the Zero and Span in Software*, for more information.

**Reset System** - The software used in the LI-6252 is also used in the LI-6262 CO<sub>2</sub>/H<sub>2</sub>O analyzer. By entering 1 for Yes you can change the configuration to that of a LI-6262 analyzer. This function is primarily for factory use only, so ordinarily this should not be changed. **Pressing 1 for Yes will remove all configuration parameters from the analyzer; they will then need to be re-entered.**

Reset System?  
1=Yes, 0=No

YES or NO.

Clearing EEPROM...

SYSTEM TYPE  
LI-62X2 (5/6)

Enter 5.

## 09 Integrate

This function allows the area under a peak to be computed. When you press FCT 09, you are prompted for the following parameters:

Prompt	Description
Source Ch=	Channel code of the quantity to be integrated.
Start = $\begin{cases} \text{On Exit} \\ \text{Thrsh} \end{cases}$	When to start the integration. 'On Exit' will start the integration immediately. 'Thrsh' will start the integration when the selected channel rises above the threshold value.
Thrsh= 0.0	If Start=Thrsh was selected above, you are prompted to enter the starting threshold value.
Stop = $\begin{cases} \text{Manual} \\ \text{Elaps tm} \\ \text{Thrsh} \end{cases}$	When to stop the integration. 'Manual' will cause the integration to continue until FCT is pressed, or until a * (asterisk) is received from the remote terminal. 'Elaps tm' (elapsed time) will cause the integration to run for the specified number of seconds. 'Thrsh' will cause the integration to continue until the target channel value drops below the threshold. <b>NOTE:</b> Pressing FCT, or receipt of a remote command (*) will always stop the integration. Pressing the display keys (1-9) will not stop the integration.
Elaps tm(s)=	If 'Stop=Elaps tm' was selected, you are prompted to enter the elapsed time, in seconds.
Thrsh=	If 'Stop=Thrsh' was selected, and 'Start=On Exit', you are prompted to enter the threshold value.

During the integration, channel 46 shows the accumulating total area A under the curve, as approximated by

$$A = \Sigma x \Delta t$$

where  $x$  is the quantity being integrated, and  $\Delta t$  is the time between readings. At the end of the integration, the non-peak area is subtracted according to

$$A = \Delta t \sum X_i - (t_e - t_s)[(X_e + X_s)/2]$$

where  $t_s$  and  $t_e$  are starting and ending times, and  $X_s$  and  $X_e$  are starting and ending values of  $x$  (Figure 5-2). Channel 46 displays this value, which will remain constant until the next integration is started.

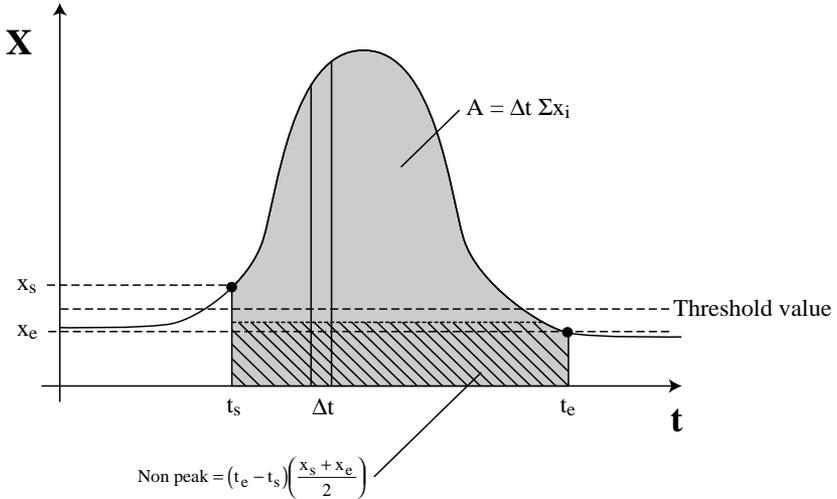


Figure 5-2. Accumulating total area  $A$  and non-peak area.

Channel 47 displays the peak value of the target channel during integration.



**\*09x,start,[start value],stop,[stop value]** ( $x$  is channel code 22-29, or 32-39 to be integrated, and  $[ ]$  denotes optional start and stop values). The  $[start]$  value is required only if  $start = 2$ , and the  $[stop]$  value is required only if  $stop = 2$  or  $3$ .

<u>Start</u>	<u>Description</u>	<u>Stop</u>	<u>Description</u>
1	On Exit	1	Manual
2	Threshold	2	Threshold
		3	Elapsed Time

**Examples:**

- \*0922,2,.5,2      Integrate channel 22 (CO<sub>2</sub> μmol/mol absolute), starting when it goes above 0.5 μmol/mol, and ending when it falls below 0.5 μmol/mol.
- \*0922,1,1      Integrate channel 22 (CO<sub>2</sub> μmol/mol absolute) starting immediately, and ending when the next \* is received.
- \*0922,2,100,3,30      Integrate channel 22 (CO<sub>2</sub> μmol/mol absolute), starting when it goes above 100 μmol/mol, and ending 30 seconds later.

**10 Print Commands**

```
10 ** PRINT **
```

```
↑,↓,↵
```

Enters menu at command 10.

## 11 Print Header

Press FCT 11 to send a column header to the RS-232C port. The headers that are printed correspond to the channels specified by the Print List (FCT 13). Appendix D lists the labels for each channel code. Function 11 may be used at any time to output a single row of column headers.



\*11

## 12 Print Data

Press FCT 12 to send a single line of data (as defined in the Print List, FCT 13), to the RS-232C port.



\*12

## 13 Set Print List

Print Col 1=0  
NEW= \_\_

Scrolls through 10 print options.

Data from up to 10 channels may be sent to the RS-232C port at a specified interval (see FCT 14). Enter up to 10 channel codes #'s 21-29, 31-39, and 41-47. If all 10 print options are not needed, press **FCT** to exit at any time.



\*13**x,x,x,x,x,x,x,x,x,x** (where x is channel code 21-29, 31-39, 41-47, and the last 9 x values are optional).

## 14 Auto Print

Print T(s)=0  
NEW= \_\_

Time interval between data transmissions through the RS-232C port.

Enter specified interval in seconds (0.2, 0.5, or 1-3600) at which to transmit data (defined at FCT 13) to the RS-232C port. The interval can be 0.2, 0.5, or any value from 1 to 3600.



**\*14x** (where x is any number 0.2, 0.5, or 1 to 3600).

## 15 Auto Header

Auto Header=0  
NEW= \_\_

Number of data lines between headers (1-999).

The column header interval is the number of data lines which will be printed between column headers. For example, entering 5 will cause a column header to be printed after every 5 lines of data.



**\*15x** (where x is any number from 1 to 999).

## 16 Print Calibration Data

Press **FCT 16** to send the current calibration stack for CO<sub>2</sub> and Miscellaneous channel codes to the RS-232C port. The output includes the calibration constants, auxiliary channel equations, and zero and span parameters for CO<sub>2</sub>. The output should look similar to this:

CO2

T: 3.5970E+01

K: 1.7913E+04

A: 1.4330E-01

B: 9.5609E-06

C: 7.8293E-09

D: -1.1040E-12

E: 7.5366E-17

Ref: 0.0000E+00

Zero: 0.0000E+00

Span: 1.0000E+00

VC:Corrections Off

MISC

AUX DEST: 43

AUX A: 5.9071E+01

AUX B: 1.5360E-02

AUX C: 0.0000E+00

AVG TIME: 1

PRESSURE: 9.6805E+01

VP CORR A: 1.5000E+00



**\*16**

## 17 Set RS-232C Port

Baud=300

↑,↓,←,→

Sets parameters for data output.

Scroll the options in the each parameter using the up and down arrow keys, and press **Enter** to select the value. The parameters for data output through the RS-232C port are as follows: (See Section 7 for further details on data communications).

**Baud rate** - 300, 600, 1200, 2400, 4800, or 9600.

**Data bits** - 7 or 8.

**Stop bits** - 1 or 2.

**Parity** - None, Even, or Odd.

**Check DTR** (Data Terminal Ready) - Yes or No. This is a hardware handshaking line. The LI-6252 looks for DTR on pin 20.

**Check XON/OFF** (Software Handshaking) - Yes or No. Controls the flow of data between transmitting and receiving devices. Receipt of Hex 13 halts transmission, receipt of Hex 11 resumes transmission.

## 18 Reset Timer

Press **FCT 18** to reset the Timer function. The Timer (FCT 45) will begin counting again at zero.



**\*18**

## 19 Full Status

Outputs the full status of the analyzer to the RS-232C port, in a format that can be read directly back into the analyzer, if desired. If you are accessing this function remotely, you can specify selected information to be sent by entering the optional parameter. For example, entering

**\*191**

would send only the \*01 (CO<sub>2</sub> Cal) information, and

**\*1913**

would send only the \*13 RS-232C print list. \*19 will produce the entire list. The entire list will appear something like this:

```
*01 3.5970E+01, 1.7913E+04, 1.4330E-01, 9.5609E-06, 7.8293E-
09, -1.1040E-12, 7.5366E-17, 0.0000E+00, 0
*05 0, 0.0000E+00, 0.0000E+00
*06 0, 0.0000E+00, 0.0000E+00
*07 1
*08 1, 0.0000E+00, 1.0000E+00
*08 2, 0.0000E+00, 1.0000E+00
*09 0,1,1
*13
*15 0
*71 5.9071E+01
*72 1.5360E-02
*73 43
*74 1
```

\*75 0.0000E+00  
\*76 0  
\*77 9.6805E+01  
\*78 1.5000E+00  
\*91 21,31  
\*92 23,29  
\*93 41,42  
\*94 31,32  
\*95 33,39  
\*96 43,44  
\*97 0,0  
\*98 0,0  
\*99 0,0



**\*19[n]** (n is optional parameter for selecting just one output channel code)

## 20 CO<sub>2</sub>

20 \*\* CO2 \*\*

↑,↓,←,→

Enters menu at function 20.

## 21-29 CO<sub>2</sub> Channel Codes

Press **FCT**, followed by the appropriate code, to view the CO<sub>2</sub> channel codes. These channels can only be viewed by pressing **FCT**; they are not executable from the main menu.

**NOTE:** CO<sub>2</sub> Reference value may be entered via the keyboard as a constant (FCT 59) or entered via analog signal. See Section 7.4.

<u>Code</u>	<u>Description</u>
21	CO <sub>2</sub> mV (non-linear)
22	CO <sub>2</sub> μmol/mol absolute
23	CO <sub>2</sub> μmol/mol differential
24	CO <sub>2</sub> Pa absolute
25	CO <sub>2</sub> Pa differential
26	CO <sub>2</sub> μg/g absolute
27	CO <sub>2</sub> μg/g differential
29	CO <sub>2</sub> μmol/mol reference

## 30 H<sub>2</sub>O Channel Codes

See Section 6.6.

## 40 Miscellaneous

40 ** MISC ** ↑,↓,↵
------------------------

Enters menu at function 40.

## 41-44 Temperature and Auxiliary

Press **FCT**, followed by the appropriate code, to view the temperature and auxiliary channel codes. These channels can only be viewed by pressing **FCT**; they are not executable from the main menu.

<u>Code</u>	<u>Description</u>
41	Temperature mV
42	Temperature °C
43	Pressure (kPa)
44	Auxiliary mV

**NOTE:** Pressure (kPa), FCT 43 is used for computations. This comes from FCT 77, or an analog signal at FCT 44 (see Section 6.4).

## 45 Timer

Timer	3.7
-------	-----

Displays accumulated time in seconds from instrument start-up.

The Timer acts as a counter which accumulates the number of seconds since instrument start-up (to 999,999), or since the Reset Timer function (FCT18) was last executed.

The Timer can also be viewed by entering "45" into any of displays 1 to 9 (FCT 91-99). The Timer function can be output to a computer or printer by entering "45" into the Set Print List function (FCT 13).

## **46 Integration A**

During the integration (FCT 09), channel 46 shows the total area A under the peak from the last integration, or the accumulating area during the present integration.



**\*46**

## **47 Integration Peak Value**

Displays the peak value of the target channel obtained during the last integration, or the largest value so far during the present integration.



**\*47**

## **49 Software Revision I.D.**



Software revision number.  
Press FCT to escape.



**\*49**

## 50 CO<sub>2</sub>

```
50 **CO2 CAL**
↑,↓,↵
```

Enters menu at function 50.

## 51-59 CO<sub>2</sub> Calibration Stack

The CO<sub>2</sub> calibration stack (FCT 51-57) contains individual CO<sub>2</sub> calibration coefficients, as well as the prompt to enter the CO<sub>2</sub> reference in μmol/mol (FCT 59).

```
C2 R=0
NEW= __
```

Enter CO<sub>2</sub> reference in μmol/mol.

<u>Code</u>	<u>Prompt</u>	<u>Description</u>
51	C2 T=	Calibration Temperature
52	C2 K=	Calibration Constant K
53	C2 A=	Calibration Coefficient A
54	C2 B=	Calibration Coefficient B
55	C2 C=	Calibration Coefficient C
56	C2 D=	Calibration Coefficient D
57	C2 E=	Calibration Coefficient E
59	C2 R=	CO <sub>2</sub> Reference μmol/mol

The CO<sub>2</sub> reference value (FCT 59) should reflect the dilution by water vapor, if the reference is not dry. For example, if the reference gas contains 300 μmol/mol CO<sub>2</sub> when dry, and 0.5 kPa of water vapor is added before it enters the reference cell, then  $C2 R = 300(1 - 0.5/P)$ , where P is the local barometric pressure.

## 60 H<sub>2</sub>O Calibration Stack

See Section 6.6.

## 70 Set Miscellaneous

70 ** MISC ** ↑,↓,↵
------------------------

Enters the menu at function 70.

The 7x functions include those necessary for using the auxiliary input channel (#15 on the back panel terminal strip). The input signal is transformed by

$$Y = A + Bx + Cx^2$$

where x is the signal in mV, and the coefficients A, B, and C are entered in FCTs 71, 72, and 75. The value Y can be treated as pressure (FCT 43), reference CO<sub>2</sub> (FCT 29) or reference H<sub>2</sub>O (FCT 39), according to FCT 73.

## 71 Auxiliary A (Offset)

Aux A= 0.0 NEW= __
-----------------------

Auxiliary A (Offset) value.



\*71<A>

## 72 Auxiliary B

Aux B=	0.0
NEW=	__

Auxiliary B value.



\*72<B>

## 73 Auxiliary Destination

Aux Dest=0	
NEW=	__

Destination channel of auxiliary input signal.

The auxiliary channel input may be sent to channel codes 29 (CO<sub>2</sub> reference), 39 (H<sub>2</sub>O reference), or 43 (pressure). Entering any other code at the NEW= prompt sets the destination to 0 and deactivates the input channel.

Setting this destination to 29, 39, or 43 causes the values of FCT 59, 68, or 77, respectively, to be ignored.



\*73X (where x is the destination channel 29, 39, 43, or <null>).

## 75 Auxiliary C

Aux C=	0.0
NEW=	__

Auxiliary C value.



\*75<C>

## 74 Average Time

Avg(s)=0 NEW= __
---------------------

Signal averaging time.

Sets the software signal averaging time, from 0 to 30 seconds. Increasing the average time decreases the noise level in any displayed channel.

The digital signal displayed is averaged over the entire time span set, after conversion from the analog signal. This results in a significant decrease in the apparent noise level, but slows the response time, as well.

This average time affects all computed values of CO<sub>2</sub> (FCTs 22 to 27), and H<sub>2</sub>O (FCTs 32-38), whether displayed, or output to a DAC channel, or output by RS-232C. It does not affect the raw mV signals on the back terminal strip.

Setting Average Time to zero will turn off all digital averaging, and the displayed or output values of CO<sub>2</sub> and H<sub>2</sub>O will reflect the hardware response time.



**\*74X** (where x is any value from 0-30 seconds).

## 76 Vapor Flag

Water corrections may be selected in the LI-6252 using FCT 76. The Vapor Flag will be set to state 2 (pressure broadening and dilution corrections to be applied) when the instrument is powered off and back on; it must be reset if you do not want to use both vapor corrections. See Sections 6.2 and 6.3 for a complete explanation of the water corrections.

Corrections Off

↑, ↓, ↵

No vapor corrections performed.  
State = "0"

Band Broadening

↑, ↓, ↵

Correct for band broadening.  
State = "1"

BandBrd, Dil → REF

↑, ↓, ↵

Band broadening & dilution corrections applied.  
State = "2"



**\*76X** (where x is 0, 1, or 2 for no correction, correct for band broadening, or correct for band broadening and dilution, respectively).

## 77 Pressure

P(kPa)=	0.0
NEW=	__

Barometric Pressure in kPa.

Barometric pressure *must* be entered correctly for CO<sub>2</sub> or H<sub>2</sub>O concentrations to be calculated correctly.

**NOTE:** Barometric pressure may also be input in Setup command 03. Pressure may also be input continuously using the 6262-03 Pressure Transducer from LI-COR, or through connector #15 on the back panel terminal strip, as described in section 7.4.



**\*77x** (where x is the barometric pressure in kPa).

## 78 Vapor Correction a

VpCrr A= 1.5	
NEW=	__

Vapor correction value a.

Vapor correction coefficient a is factory-entered (a = ~ 1.5). See Section 6.4 for a description of the vapor correction. This value is only used when Vapor Correct (FCT 76) is in State 1 or 2.



**\*78a** (where a is the value of vapor correction a).

## 80 D/A Conversions

80 \*\* DAC \*\*  
 ↑,↓,↵

Enters the menu at function 80.

The digital-to-analog converter (DAC) converts a digital value from channels 22-27, 32-38, or 42 into a calibrated analog voltage proportional to any units. There are two such channels (DAC 1, DAC 2) available on the instrument back panel.

Three output ranges are available for DAC 1 and DAC 2 on the LI-6252 back panel terminal strip; 0-5V, 0-100 mV, and 4 to 20mA.

To convert voltage output V to the value X that is driving it,

$$X = \left( \frac{X_F - X_0}{R} \right) V + X_0$$

where R = full scale voltage range (5V or 100mV),

$X_F$  = the value of X corresponding to full scale voltage (set in FCT 83 or 86), and

$X_0$  = the value of X corresponding to zero volts (set in FCT 82 or 85).

For current I,

$$X = \left( \frac{X_F - X_0}{16} \right) I + \frac{5X_0 - X_F}{4}$$

where  $X_F$  is the value of X corresponding to 20mA, and  $X_0$  is the value of X corresponding to 4mA, the minimum X value expected, because unlike the voltage outputs, the current output cannot go negative.

The output resolution of X will be

$$\Delta X = 4.88 \times 10^{-4} (X_F - X_0) \quad \text{[voltage]}$$

and

$$\Delta X = 2.44 \times 10^{-4} (X_F - X_0) \quad \text{[current]}.$$

If voltage is measured, the 0-5V range should be used whenever possible. The 0-100 mV range is provided for measuring or logging devices with a more limited voltage range; some resolution may be lost due to signal noise considerations when using the smaller output range.

The output impedance of the 0-100 mV range is 50-100 $\Omega$ , so a measuring or logging device with a high input impedance should be used.

Note that resolution is maximized by minimizing the range to be covered. For example, if you are making CO<sub>2</sub> measurements that are always less than 400 ppm, set the DAC to cover only that range, rather than 0 to 1000 or 0 to 3000.

## 81 D/A Conversion Code #1

DAC 1 Code=  
NEW= \_\_

Channel code for digital to analog conversion #1.

Enter channel code # 22-27, 32-38, or 42 as the channel to output through analog output channel #1.

## 82 D/A Conversion #1 Minimum

1 0V=  
NEW= \_\_

Digital channel value which corresponds to 0V or 4mA on DAC #1.

## 83 D/A Conversion #1 Maximum

1 5V=  
NEW= \_\_

Digital channel value which corresponds to full scale (5V, 100mV, or 20mA) on DAC #1.

## **84 D/A Conversion Code #2**

DAC 2 Code= NEW= __
------------------------

D/A Conversion #2 (same as 81).

## **85 D/A Conversion #2 Minimum**

2 0V= NEW= __
------------------

Digital channel value which corresponds to 0V or 4mA on DAC #2.

## **86 D/A Conversion #2 Maximum**

2 5V= NEW= __
------------------

Digital channel value which corresponds to full scale (5V, 100mV, or 20mA) on DAC #2.

## 90-99 Displays

90 \*\* DISP \*\*

↑,↓,↵

Enters menu at function 90.

Nine two-line displays can be defined with functions 91-99. Function 91 defines display 1, accessed by pressing the "1" key, 92 defines display 2, etc. Displayable quantities are 21-29, 31-39, or 41-47.

All displays can be defined in one operation at FCT 04, or they can be defined individually using FCT 91-99, as shown below.

1 Top=

New= \_\_

Channel code for top of display 1.

1 Bottom=

NEW= \_\_

Channel code for bottom of display 1.



**\*91x,x, \*92x,x, \*93x,x** etc. (where x is any channel code 21-27, 29, 31-39, and 41-47).



# 6 H<sub>2</sub>O Corrections

## 6.1 General Information

The software in the LI-6252 is the same as that of the LI-6262 CO<sub>2</sub>/H<sub>2</sub>O Gas Analyzer. Notice that the console command sheet contains H<sub>2</sub>O channel codes 02, 30-39, 60-68, 76, and 78-79, which can be accessed in the LI-6252 software.

For normal operation of the LI-6252, these H<sub>2</sub>O console commands are not used. However, if an analog signal from an external dewpoint hygrometer is provided, it is possible to configure the LI-6252 to correct CO<sub>2</sub> measurements for the influence of water vapor.

The following sections will describe how water vapor affects CO<sub>2</sub> measurements, and how to perform the water corrections. This discussion can be skipped if you are not interested in using this particular function.

## 6.2 Pressure Broadening Due to Water Vapor

Water vapor can influence infrared detection of CO<sub>2</sub> in three ways: 1) direct absorption in the CO<sub>2</sub> waveband of interest, 2) dilution, and 3) pressure broadening. Direct infrared absorption by water vapor can be virtually eliminated by judicious choice of wavebands and filters, and methods to correct for dilution are well known (Section 6.3); however, pressure broadening is more of a problem.

Gas phase absorption of infrared radiation is due to energy-induced changes in vibrational, rotational, and translational energy states. Such energy states are altered by intermolecular collisions which increase in number as pressure increases. The kinetic theory of gases and quantum mechanics predicts that absorption band widths increase with pressure, and it is observed that broad band infrared absorption increases as pressure increases at constant absorber concentration.

Not all gases are equally effective in causing pressure-induced line broadening. Gases that are similar are more effective than dissimilar gases.

## Section 6

---

This effect is embodied in the concept of equivalent pressure, or effective pressure,  $P_e$  (1,3). Total pressure  $P$  is equal to the sum of partial pressures of component gases, while equivalent pressure is defined as

$$P_e = a_1 p_1 + a_2 p_2 + \dots$$

where  $a_i$  are weighting factors representing the pressure broadening effectiveness of each gas species relative to nitrogen ( $a_{N_2} = 1$ ). For  $CO_2$  in nitrogen  $P_e = p_{N_2} + 1.3 p_{CO_2}$  (2).

Consider a simple atmosphere made up of  $H_2O$  vapor with partial pressure  $e$ , plus dry gases with pressure  $P_d$ , so that

$$P = P_d + e,$$

or, in mole fraction units,

$$1 = X_d + X_w \quad 6-1$$

where  $X_d$  is the mole fraction of all dry gases and  $X_w$  is the water vapor mole fraction ( $e/P$ ).

The equivalent pressure will be  $P_e = \sum a_i p_i + a_w e$ . In principle,  $P_e$  will vary with  $CO_2$  partial pressure, but the  $CO_2$  partial pressure is so small that it can be neglected. Thus, if other atmospheric components are constant, an equivalent pressure can be defined as

$$\begin{aligned} P_e &= a_d P_d + a_w e. \\ &= P(a_d X_d + a_w X_w) \end{aligned} \quad 6-2$$

where  $P_d$  is the total pressure of dry air, and  $a_d$  is a dry air weighting factor.

LI-COR calibrates all of its analyzers using  $CO_2$  or water vapor in air, so  $a_d = 1$  is taken as the standard condition. Substituting equation 6-1 into equation 6-2 gives

$$P_e = P[1 + (a_w - 1)X_w] \quad 6-3$$

The value of  $a_w$  is not an intrinsic constant comparable to other such values in the literature because it uses dry air as a reference instead of nitrogen. Its

value has been empirically determined to be about 1.5 against dry air. The value of  $a_w$  used in 6-3 is entered into the LI-6252 using FCT 78.

Equation 6-3 can be extended to include nitrogen as standard, and both water vapor and oxygen (or other gases) as variable components.  $P_e$  can be written in a more general form to anticipate that possibility:

$$P_e = P[1 + (a_w - 1)X_w + \sum(b_i - 1)X_i] \quad 6-4$$

For the present, equation 6-3 is implemented in the LI-6252 software; equation 6-4 has not yet been tested. Equation 6-3 can be compactly rewritten as

$$P_e = P\chi(X_w), \quad 6-5$$

where  $\chi(X_w) = 1 + (a_w - 1)X_w$ , and then incorporated into the CO<sub>2</sub> calibration function.

The form of the CO<sub>2</sub> calibration function (equation 3-4) was derived empirically, but it can also be derived from a "scaling law" called the "non-overlapping line approximation" which holds when absorber concentrations are low or pathlengths are short (3). This "scaling law" allows absorption measured under one set of conditions to be scaled to other conditions (1),

$$\frac{A}{P} = g(u/P) \quad 6-6$$

where A is total band absorption, P is total pressure (kPa), u is absorber amount (mol m<sup>-2</sup>) =  $\rho L$ ;  $\rho$  is mol density (mol m<sup>-3</sup>), and L is pathlength (m); g is a general unspecified function.

From the ideal gas law, the absorber mole density  $\rho$  can be expressed as

$$\begin{aligned} \rho &= \frac{p}{RT} \\ &= \frac{XP}{RT} \end{aligned} \quad 6-7$$

where  $p$  is absorber partial pressure and X is absorber mole fraction (mol absorber/mol air). Therefore,

## Section 6

---

$$\frac{u}{P} = \frac{XL}{RT} \quad 6-8$$

Substituting equation 6-8 into 6-6 and incorporating the constants L and R into a new function h gives

$$\frac{A}{P} = h\left(\frac{X}{T}\right) \quad 6-9$$

In principle, equation 6-9 can be solved for mole fraction, giving

$$X = h^{-1}\left(\frac{A}{P}\right)T \quad 6-10$$

Since LI-COR gas analyzers produce an output voltage that is proportional to absorbance,

$$V=KA \quad 6-11$$

substituting 6-11 into 6-10 yields

$$C = F\left(V\frac{P_o}{P}\right)\left[\frac{T}{T_o}\right] \quad 6-12$$

where C is the CO<sub>2</sub> mole fraction in μmol mol<sup>-1</sup>, and the constants K, P<sub>o</sub> and T<sub>o</sub> are included in the general function F; P<sub>o</sub> = 101.3 kPa, and T<sub>o</sub> is the calibration temperature in degrees Kelvin. Equation 6-12 is the fundamental LI-COR gas analyzer calibration function, where F(x) is a polynomial. By substituting equation 6-5 into 6-6 and following through the derivation, the calibration equations for CO<sub>2</sub> become:

$$V_r = \chi(w_r)F^{-1}\left(\frac{c_r}{\chi(w_r)}\left[\frac{T+273}{T_o+273}\right]\right)\frac{P}{P_o}$$

$$G = 1 - \frac{V_r}{K} \quad 6-13$$

$$C = \chi(w_s)F\left(\frac{VG + V_r}{\chi(w_s)}\frac{P_o}{P}\right)\frac{T+273}{T_o+273}$$

$$\Delta C = C - C_r$$

The water correction is based upon a theoretically justifiable procedure which requires determination of a single physically meaningful constant, and can be applied to any LI-COR 6200 series infrared gas analyzer, and perhaps others, as well.

### 6.3 Dilution Corrections

A dilution correction can be applied in the LI-6252, if desired. When one component gas of a multicomponent mixture is decreased at constant pressure, the partial pressures of all other components are increased accordingly. For example, if water vapor is removed at constant pressure, then the partial pressures of other components increase according to

$$P = \frac{\sum p_i^{\text{wet}}}{(1 - w/1000)} \quad 6-14$$

where  $w$  is the water vapor mole fraction (mmol/mol) and the  $p_i^{\text{wet}}$  are partial pressures of other component gases before water vapor was removed. For individual components, Equation 6-14 becomes

$$p_i^{\text{dry}} = \frac{p_i^{\text{wet}}}{(1 - w/1000)} \quad 6-15$$

It is often necessary to correct the  $\text{CO}_2$  mole fraction for differences in water vapor mole fraction in sample and reference cells when  $\text{CO}_2$  and water vapor are measured together. An apparent  $\text{CO}_2$  mole fraction difference will develop if water vapor is added to or removed from either air stream whether a net  $\text{CO}_2$  flux is present or not. This dilution effect can be removed when the Vapor Flag (FCT 76) is set to **BndBrd, Dil** → **Ref**; the  $\text{CO}_2$  mole fraction in the sample air stream is then corrected to the water vapor mole fraction that is in the reference air stream according to

$$C_s^{\text{wr}} = C_s^{\text{ws}} \frac{(1 - w_{\text{ref}}/1000)}{(1 - w/1000)} \quad 6-16$$

$C_s^{\text{ws}}$  is the actual  $\text{CO}_2$  mole fraction in the sample cell diluted by  $w$ , and  $C_s^{\text{wr}}$  is the equivalent sample cell  $\text{CO}_2$  mole fraction if it were diluted by  $w_{\text{ref}}$ .

## Section 6

---

It is important to distinguish the different water corrections that can be applied in the LI-6252. The Vapor Flag (FCT 76) can be in one of three states:

**0 - Corrections Off:** No water calculations of any kind are performed.

**1 - Band Broadening:** A pressure broadening correction is applied, but no dilution correction is performed. The actual CO<sub>2</sub> mole fraction in the sample cell or the actual CO<sub>2</sub> differential is displayed.

**2 - BndBrd, Dil → Ref:** Both a pressure broadening and a dilution correction are applied. The sample cell CO<sub>2</sub> mole fraction and the CO<sub>2</sub> differential are corrected for differences in sample and reference air stream water vapor contents. **NOTE:** This is the default setting when the system is reset (FCT 08).

If you wish to log a signal from a dewpoint hygrometer, and calculate water vapor mole fraction, etc., but not perform a water correction, set the Vapor Flag (FCT 76) to State "1" (Band Broadening) and  $a_w$  (FCT 78) to 1.

## 6.4 Calculating H<sub>2</sub>O Concentration

The LI-6252 does not measure water vapor directly, but it can compute dewpoint, vapor pressure, mole fraction, and weight fraction using a mV signal from an external dewpoint hygrometer. Water vapor mole fraction data can then be used to correct CO<sub>2</sub> measurements for dilution and pressure broadening due to water vapor, and the water vapor data can be output via the RS-232C port along with CO<sub>2</sub> measurements. **Note, however, that water vapor calculations will only be performed when the Vapor Flag (FCT 76) is set to 1 or 2.**

A mV signal from a dewpoint hygrometer is received at the **H<sub>2</sub>O INPUT** terminal on the back panel terminal strip. It is assumed that the signal can be represented by a third order polynomial with offset

$$T_d = K + AV + BV^2 + CV^3 \quad 6-17$$

The calibration polynomial coefficients are stored in the water calibration list (FCT 02), along with a calibration temperature which is not used in the LI-6252, and the reference cell water vapor mole fraction ( $W_{REF}$ ), which is discussed below. Dewpoint hygrometers often provide a voltage output which is linear with dewpoint, so all coefficients but A may be zero. These polynomial coefficients should be provided by the hygrometer manufacturer.

Vapor pressure is computed from the dewpoint temperature according to Lowe (1976):

$$e(T) = (a + bT + cT^2 + dT^3 + eT^4 + fT^5 + gT^6)/10 \quad 6-18$$

where T = dewpoint temperature (°C)

e(T) = vapor pressure (kPa)

$$a = 6.1078$$

$$b = 4.4365 \times 10^{-1}$$

$$c = 1.4289 \times 10^{-2}$$

$$d = 2.6505 \times 10^{-4}$$

$$e = 3.0312 \times 10^{-6}$$

$$f = 2.0341 \times 10^{-8}$$

$$g = 6.1368 \times 10^{-11}$$

Mole fraction is given by

$$W = 1000 \frac{e}{p} \quad 6-19$$

## Section 6

---

where  $w$  = mole fraction ( $\text{mmol mol}^{-1}$ )

$e$  = vapor pressure (kPa)

$P$  = barometric pressure (kPa)

Weight fraction is computed as

$$w_g = \frac{18w}{M} \quad 6-20$$

where  $w_g$  = weight fraction ( $\text{mg g}^{-1}$ )

$M$  = formula weight of moist air ( $\text{g mol}^{-1}$ )

$$= 29(1 - w/1000) + 18w/1000$$

Differential water vapor mole fraction is computed as the difference  $w - W_{\text{REF}}$ , where  $W_{\text{REF}}$  ( $\text{mmol mol}^{-1}$ ) is the water vapor mole fraction in the reference cell.  $W_{\text{REF}}$  must be fixed with a dewpoint generating device or found by prior measurement, and entered as a parameter in the water calibration list (FCT 02). Water vapor mole fraction in the sample cell is computed from the hygrometer input without using  $W_{\text{REF}}$ , but all differential values are computed by difference after converting  $w$  and  $W_{\text{REF}}$  to appropriate units.

## 6.5 Analog Inputs

An analog signal may be input to the LI-6252 from an external dewpoint hygrometer. Connect the hygrometer as shown in Figure 6-1. The positive lead from the hygrometer is connected to the terminal labeled **H<sub>2</sub>O INPUT** and the negative lead is connected to the terminal labeled **SIG GND**.

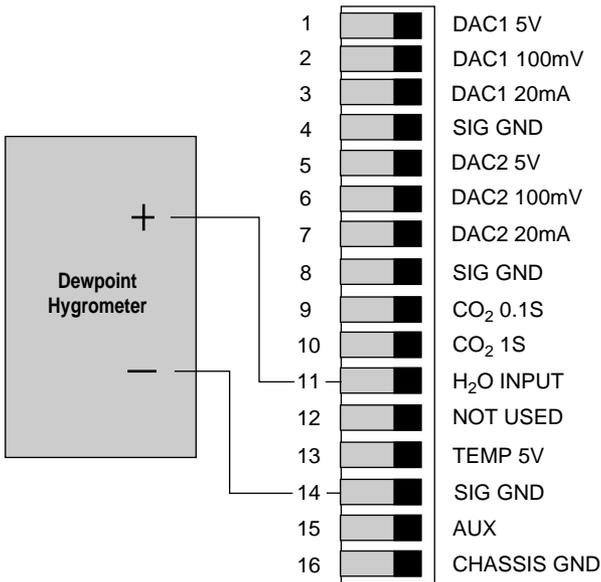


Figure 6-1. Connection of an external dewpoint hygrometer for analog signal input.

### 6.6 Software Configuration

The software function codes used to enter H<sub>2</sub>O calibration coefficients and display H<sub>2</sub>O channel codes are accessed in the same manner as described in Section 5.3 for CO<sub>2</sub> calibration coefficients.

#### 02 H<sub>2</sub>O Calibration

Setup command 02 is used to enter H<sub>2</sub>O calibration coefficients T,K,A,B, and C. These values correspond to the millivolt output of the dewpoint hygrometer, and are found by generating a calibration polynomial of the form:

$$\text{Dewpoint} = K + AmV + BmV^2 + CmV^3$$

In its simplest form, the dewpoint would be directly proportional to the millivolt output of the dewpoint hygrometer, in which case the equation would become:

$$\text{Dewpoint} = AmV, \text{ where } K=B=C=0$$

Press FCT 02. The display will appear as

H2 T= __ NEW= __
---------------------

H<sub>2</sub>O calibration temperature.  
This is not used in the LI-6252.

An entry is not necessary for H2T; however, prompts for new values of K, A, B, C, and REF will follow. Enter all coefficients, followed by **ENTER**. These values may also be entered individually at function codes 61-68. Press **FCT**, followed by 61-68 to access these function codes.



**\*02, K, A, B, C, REF**

## 30 H<sub>2</sub>O Channel Codes

30 \*\* H2O \*\*  
 ↑, ↓, ↵

Enters menu at function 30.

Channel codes 31-39 display H<sub>2</sub>O in units of mmol/mol, kPa, mg/g, and Dew point. These functions display values only; no user input is required.

## 60 H<sub>2</sub>O Calibration

60 \*\*H2O CAL\*\*  
 ↑, ↓, ↵

Enters menu at function 60.

The H<sub>2</sub>O calibration stack contains codes for entering H<sub>2</sub>O calibration coefficients, as described at FCT 02.

## 76 Vapor Flag

Water corrections may be selected in the LI-6252 using FCT 76. The Vapor Flag will be zero (Corrections Off) when the instrument is received from the factory, but the default setting is for both pressure broadening and dilution corrections to be applied if a System Reset (FCT 09) is performed, and when the instrument is powered off. See Sections 6.2 and 6.3 for a complete explanation of the vapor corrections.

Corrections Off  
 ↑, ↓, ↵

No vapor corrections performed. State = "0"

No water vapor calculations of any kind will be performed when the Vapor Flag = 0. Press **ENTER** for corrections off, or ↓ for band broadening correction only.

## Section 6

---

Band Broadening

↑, ↓, ↵

Correct for band broadening.  
State = "1"

Press **ENTER** for band broadening correction, ↓ for band broadening and dilution corrections, or ↑ for no correction.

BandBrd, Dil → REF

↑, ↓, ↵

Band broadening & dilution  
corrections applied.  
State = "2"



**\*76x** (where x is 0, 1, or 2 for no correction, correct for band broadening, or correct for band broadening and dilution, respectively).

## 78 Vapor Correction a

VpCrr A= 1.5

NEW= \_\_

Vapor correction value a.

Vapor correction coefficient a is factory-entered (a = 1.5). See Sections 6.2 and 6.3 for descriptions of the vapor correction. This value is only used when Vapor Correct (FCT 76) is in either state 1 or 2.



**\*78a** (where a is the value of vapor correction a).

## References

1. Jamieson, J.A., et.al. 1963. Infrared Physics and Engineering. McGraw-Hill, New York, N.Y. p. 65.
2. Lowe, P.R. 1976. An approximating polynomial for the computation of saturation vapor pressure. J. Appl. Meteor., 16:100-103.
3. Wolfe, W.L., and G.J. Zissis. 1978. The Infrared Handbook. Office of Naval Research, Department of the Navy, Washington, D.C.



# 7

## Interfacing

### 7.1 General Information

Data can be obtained from the LI-6252 in three ways: 1) from the display; 2) from the RS-232C port; or 3) from one of the analog output channels.

#### RS-232C Output

Up to 10 different channels can be output (in columnar form) at a user-specified time interval, or in response to a command (FCT 12). Data are transmitted as ASCII characters that can be captured with a computer or printed on a printer. The following communication parameters can be set in the LI-6252 software (FCT 17):

Baud Rate: 300, 600, 1200, 2400, 4800, or 9600.

Data Bits: 7 or 8

Stop Bits: 1 or 2

Parity: Odd, Even, or None.

Check DTR: Yes, No

Check XON/XOFF: Yes, No

#### Analog Output

Two linear voltage output channels are provided which have 0-100mV or 0-5V ranges. The signals for these channels can be scaled over any concentration range in any units (see Section 5.3, FCT 80). The linear channels are available after digital to analog conversions of any channel code 22-27 or 42.

Two analog channels are also available for the raw CO<sub>2</sub> analyzer outputs. Electronic filters provide both 0.1 second and 1 second response times for CO<sub>2</sub>. Units having serial numbers less than IRG2-244 had 1 and 4 second response times, unless modified by the 6252-01 option.

### 7.2 RS-232C Data Transfer

#### Selecting a Cable

RS-232C ports on computers and printers often use 25-pin "D" connectors, but this is not always the case. The back panel of a typical IBM PC might have 2 such connectors; one male and one female. The female connector is usually the parallel interface and the male connector is usually the RS-232C port. However, an RS-232C port might use male or female connectors, so verify what is present before connecting anything to it. *It is possible to damage a serial interface by connecting it to another type of interface.*

The RS-232C port on the LI-6252 is the female 25-pin "D" connector on the back panel labeled "RS-232C DCE". The LI-6252 is configured as Data Communications Equipment (DCE), which means that it can communicate directly with computers, RS-232C printers, and other devices configured as Data Terminal Equipment (DTE) using only a cable that has pin-for-pin connections between the connectors on each end. The LI-COR 1000-04 RS-232C cable will work with most computers and printers with a 25-pin connector, and the 1800-04 RS-232C cable will work with most computers that have a 9-pin AT style RS-232C port. Most other cables that are manufactured for DCE to DTE RS-232C data communications will also work.

If your computer is configured as DCE (not normally the case), use the 1000-03 RS-232C cable or any other cable that can act as a null modem (DCE to DCE in this case).

## Software Configuration

Functions 11-17 are used to set up RS-232C data transfer. They can be accessed directly or via the PRINT stack (FCT 10). The following example illustrates how to configure the LI-6252 to transmit differential CO<sub>2</sub> (channel code 23) and analyzer temperature (channel code 42) through the RS-232C port. Data are captured with the 1000-90 COMM program, or any other general purpose ASCII capture program.

1. Set the communication parameters (FCT 17) as follows:

Baud Rate: 4800  
Data Bits: 8  
Stop Bits: 2  
Parity: None

This configuration is appropriate for an IBM PC or compatible using the 1000-90 software described in the following section. Connect the appropriate cable.

2. To test the cable connections and make sure that the computer software is configured properly, press FCT 16, which will print a list of the current calibration data for the LI-6252. If nothing is sent, make sure that the cable connections are correct, and then consult the software manual for the software you are using.
3. Press FCT 13 and designate channels 23 and 42 as the channels to print.
4. Press FCT 15 to print a header after every 20 lines of data are output.
5. Press FCT 14 to set the print interval to 1 second.
6. The data should look similar to this:

dC2 $\mu$ m/m	Temp C
50.000	21.993
50.000	21.998

Alternatively, to print a single header or one line of data, use functions 11 and/or 12, as needed, after setting the print interval (FCT 14) to zero.

### Using an IBM PC Compatible Computer

The 1000-90 Communications and Utility Software included with the LI-6252 will enable the analyzer to interface with any PC-compatible computer with an RS-232C port.

Follow the instructions included with the 1000-90 to load the **COMM** program. The 1000-90 instructions describe how to run the **COMM** program using the softkeys F1 thru F9. Here are some tips for using the program with the LI-6252:

**F1** - Accesses the configuration menu. Select the configuration labeled "General Purpose" by pressing **Enter**.

**F2** - Change COM. Notice that pressing F2 will toggle between COM1 and COM2 on the screen menu. Use this to select the communications port which is connected to the computer, if different than the default setting.

**F3** - Local echo ON or OFF. Toggles between ON and OFF. Having the echo ON is useful to view the characters on the CRT which are typed if a computer is used to backload remote commands to the LI-6252.

**F6** - File. Specifies the file into which incoming data will be copied (if desired). Specify both the filename and the path where you want to copy the data file. For example, typing C:\DATA will create an ASCII file named DATA on the root directory of drive C. Further manipulation of the data file can be accomplished with any software program that can read data from a generic text file.

There are several other inexpensive communication programs which may be used to interface the LI-6252 to a computer. Two such programs for IBM PC's and compatibles are PC TALK (Freeware, P.O. Box 862, Tiburon, CA 93920) and ProComm (Data Storm Technologies, Inc., P.O. Box 1471, Columbia, MO 65205). Either of these programs will allow ASCII data sent from the LI-6252 to be displayed on the computer terminal or stored in a disk file.

## Sending Remote Commands to the LI-6252

The 1000-90 software program may also be used to send remote commands to the LI-6252. On the LI-6252 Console Command sheet there is a section entitled "remote commands". Most LI-6252 commands are duplicated by the remote commands, which may be typed on the terminal at any time during the execution of the COMM program, even while data is being transmitted. Typed characters are viewed by toggling the F3 key to change to ECHO ON.

Type the remote commands exactly as they appear on the command sheet. For example, typing \* (asterisk)1530 will change the Auto Header command to 30 seconds in the LI-6252. The first two digits identify the channel to be edited, followed by appropriate arguments for that channel. The arguments may be channel numbers, calibration values, or flags (e.g. Y,N), depending upon the channel edited. If more than one argument is required, the first follows the channel identifier without a space or comma, and subsequent arguments (if any) are separated by commas only. For example, typing \*1321,22,23,29,41 will change the print list which is output to your terminal to channel codes 21, 22, 23, 29, and 41.

## Uploading ASCII Files to the LI-6252

Remote commands can be written in an ASCII file and copied out the serial port. The LI-6252 will read and execute the commands sequentially as they are received. Any word processor or text editor that can write standard ASCII files is suitable for setting up the configuration file. It is important to save the file in a "Text only", "ASCII only", or "Non-Document" mode. Here is a simple example of how a command file might be sent to the LI-6252:

Prepare the following ASCII file and name it DATA.

```
*744                (Sets signal averaging time to 4
                    seconds)
*1321,23,25,42,43  (Sets print list)
*1430              (Sets Auto Print to 30 seconds)
*1510              (Sets Auto Header to 10 seconds)
*762               (Turns Vapor Flag to State "2")
*9121,23          (Sets Display 1 to channel codes
                    21 and 23)
```

## Section 7

---

Upload the file from DOS by typing:

```
COPY filename COM1
```

This will copy the contents of the file to the serial port (use COM2 if that is the one to which the LI-6252 is connected). You may need to reset the communication parameters (Baud Rate, Parity, etc.) as well, using the DOS MODE command.

Note that you can create a complete configuration file for your LI-6262 by first capturing the data generated using remote command \*19, and then editing the file (if desired). When this file is sent back to the LI-6262, it will configure all elements in its software.

### Using an Apple Macintosh

Sending data to the Macintosh requires a Hayes compatible modem cable for the Macintosh. Most Hayes modem cables terminate with a male 25-pin "D" connector that will plug directly into the LI-6252. In the event that your cable has the wrong gender, use a female-to-female gender changer with pin-for-pin connections.

A number of data transfer software programs are commercially available. The 1000-91 Communication Software is available free of charge from LI-COR.

### Using a Printer

The LI-6252 can communicate with virtually any printer having an RS-232C interface. One example is the 6000-03B printer from LI-COR, which is an Epson printer with an RS-232C interface installed. The LI-6252 is connected to the 6000-03B printer using the 1000-04 RS-232C cable.

## Solving Communication Problems

A few common communication problems and possible causes are given below:

### PROBLEM

### WHAT TO CHECK

Nothing happens	Wrong cable. Connections tight? Handshake?
All characters are wrong	Baud rate set wrong.
Some characters are wrong	Data bits, stop bits, or parity wrong.

The most common problem in RS-232C communications is the use of the wrong cable. If you have communication problems that cannot be resolved, you may wish to purchase an RS-232C indicator card (Model #9960-031). This card indicates which lines in the cable are being used and generally indicates where the problem is.

If the output buffer (512 bytes) becomes full, the message "Too much Data or Baud Rate too low" will be displayed. This can happen at lower baud rates, or if the handshaking (XON/XOFF or DTR) is preventing the data from being sent.

## 7.3 Analog Output

Analyzer output can be recorded by connecting a logging device to the terminal strip on the back of the analyzer. Both linear outputs (scaled over any range and in any units) and non-linear outputs are available.

### Measuring Linear Analyzer Output

The LI-6252 has two D/A Converters (DAC's), which can be used to convert calculated quantities (your choice of channels 22-27 or 42) to an analog signal (-5V to +5V, -100mV to +100mV, or 4mA to 20mA ranges). The voltage and current ranges are selected by choosing the appropriate terminals on the back panel terminal strip.

DAC #1 is configured using FCT 05 (or FCTS 81-83), and DAC #2 is configured using FCT 06 (or FCTS 84-86).

## Section 7

---

A DAC is configured by specifying the source channel (e.g. 22, 23, etc.) which will drive the analog signal, the source channel value which corresponds to zero volts (or 4mA), and the source channel value which corresponds to full scale voltage (or 20mA).

For example, to configure DAC #1 to output a voltage signal proportional to differential CO<sub>2</sub>, 100 µmol/mol full scale, press FCT 05 and set

DAC 1 Code = 23                      (Differential CO<sub>2</sub> channel)  
1 0V → 0                              (X<sub>0</sub>, zero volts corresponds to 0 µmol/mole)  
1 5V → 100                             (X<sub>F</sub>, full scale corresponds to 100 µmol/mole)

When a voltage range R is selected, the DAC output voltage V resulting from a CO<sub>2</sub> differential X is given by

$$V = R \frac{X - X_0}{X_F - X_0}$$

where R = 5V or 100mV. If the 4 to 20mA current loop is selected, the output current I (milliamps) is

$$I = 16 \frac{X - X_0}{X_F - X_0}$$

To convert the DAC1 output signal to µmol/mol (or other units),

$$X = \left( \frac{X_F - X_0}{R} \right) V + X_0$$

For the 4 to 20mA channel,

$$X = \left( \frac{X_F - X_0}{16} \right) (I - 4) + X_0$$

or, in terms of a slope and offset,

$$X = \left( \frac{X_F - X_0}{16} \right) I + \frac{5X_0 - X_F}{4}$$

**NOTE:** The 20mA signal will not go negative. If you wish to use the 20mA option, configure the DAC so that the signal will always be positive. For example, to allow a range of -100 to +100  $\mu\text{mol/mol}$ , set  $X_0 = -100$ , rather than 0. Then, -40  $\mu\text{mol/mol}$  will generate an 8.8 mA signal on DAC 1 20 mA.

## Resolution

The DAC's are 12-bit bipolar devices, so resolution is given by (total range)/ $2^{12}$ . The voltage ranges can go positive or negative, so resolution is  $\pm R/2^{12} = R/2^{11}$ . This corresponds to 2.44 mV on the 5V range, and 48.8  $\mu\text{V}$  on the 100 mV range. The 4 to 20mA range does not go negative, so its resolution is  $(20-4)/2^{12} = 3.91 \mu\text{A}$ . The smallest difference that can be resolved for any variable is,

$$\Delta X = 2^{-11} (X_F - X_0) = 4.88 \times 10^{-4} (X_F - X_0) \text{ [voltage]}$$

and

$$\Delta X = 2^{-12} (X_F - X_0) = 2.44 \times 10^{-4} (X_F - X_0) \text{ [current]}$$

As an example, if  $X_F = 1000$  and  $X_0 = 0$ , the resolution will be about 0.5  $\mu\text{mol/mol}$  on either voltage channel, and 0.25  $\mu\text{mol/mol}$  on the current channel.

## Timing

The DAC outputs change whenever the target channel changes. All of the  $\text{CO}_2$  values (FCTs 22-27) are computed at 5 Hz. Users needing high speed regular sampling should use the non-linear outputs for  $\text{CO}_2$  if >5 Hz is required.

### Terminal Connections - Voltage

Figure 7-1 shows an example connection of a data acquisition device to the LI-6252 to measure the linear output of channel #1.

- Connect the positive input of the data logger to the terminal labeled **DAC1 5V** (or **DAC1 100mV**).
- The negative input should be connected to the terminal labeled **SIG GND**.
- Connect another input from the data logger to the terminal labeled **DAC2 5V** (or **DAC2 100mV**) to measure the linear output of channel #2.

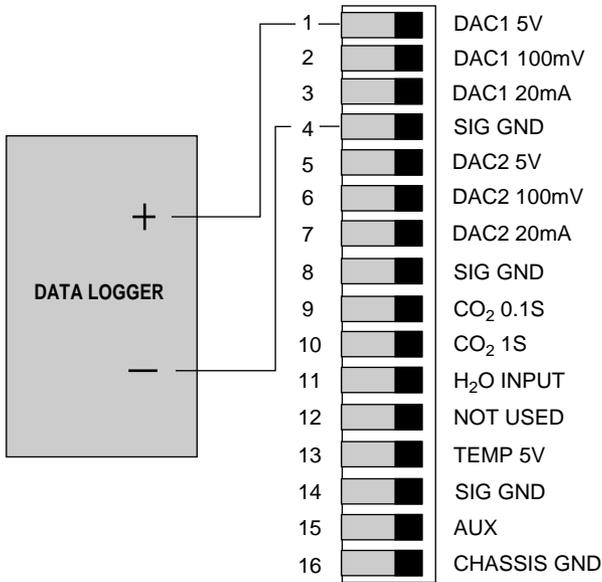


Figure 7-1. Connection of data logger for linear output.

## Terminal Connections -Current

Figure 7-2 shows the proper connection of a data acquisition device to the LI-6252 terminal block.

- Connect the positive input of the data logger to the terminal labeled **DAC1 20mA** for channel one, or **DAC2 20mA** for channel two.
- Connect the negative input to one of the terminals labeled **SIG GND**.

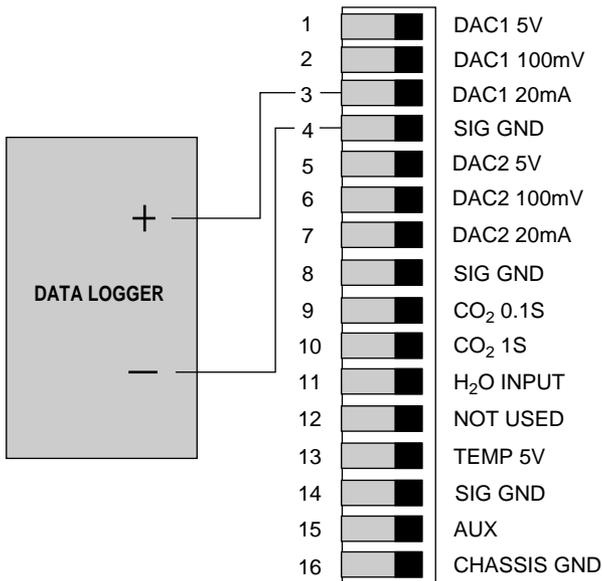


Figure 7-2. Connection of data logger for current loop output.

### Measuring Raw (Non-linear) Analyzer Output

To measure the non-linearized voltage output of the CO<sub>2</sub> analyzer (0.1 second response time) with a meter or data logger:

- Connect the positive input of the data logger to the terminal labeled **CO<sub>2</sub> 0.1S** (see Figure 7-3).
- Connect the negative input to the terminal labeled **SIG GND**. If the cable from the data logger is shielded, the shield can be connected to the **CHASSIS GND** terminal.
- To measure analyzer temperature or the voltage output with a different response time, connect the appropriately labeled terminal to the positive input of another channel on the data logger.

The resolution which the data acquisition device should have is dependent upon the noise level of the analyzer (0.2 μmol/mol CO<sub>2</sub> typical, 0.4 μmol/mol maximum).

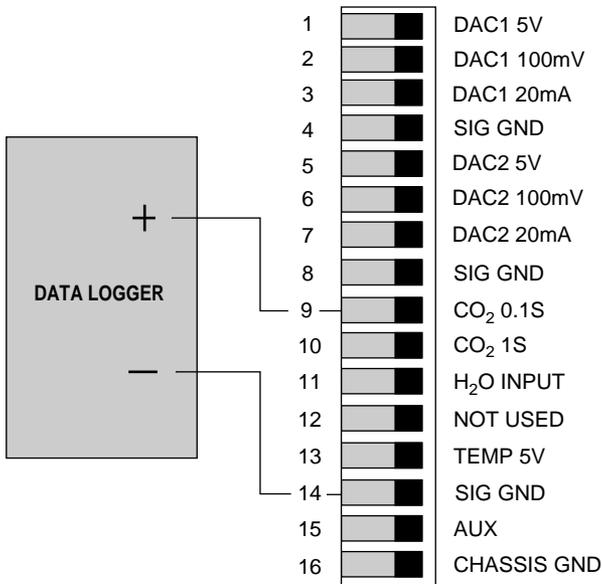


Figure 7-3. Connection of data logger for non-linear output.

## 7.4 Auxiliary Channel Inputs

Terminal 15 is connected to the auxiliary channel which may be used to input an analog signal from a user-supplied external sensor. CO<sub>2</sub> and H<sub>2</sub>O references may be input through this channel, as well as barometric pressure. Use FCT 73 to designate the channel (29, 39, or 43) to which the analog signal will be sent. Figure 7-4 shows how to connect a sensor to the terminal strip on the back panel of the LI-6252.

**NOTE:** If the 6262-03 Pressure Transducer is installed in your analyzer, the auxiliary channel input is no longer available; the raw mV reading from the transducer can be *measured* at this terminal, however. Please see Section 7.6 for a complete discussion of the 6262-03.

- Connect the positive input from the sensor to the terminal labeled **AUX**.
- Connect the negative input to the terminal labeled **SIG GND**.

The auxiliary channel has an input voltage range of  $\pm 4.096V$ .

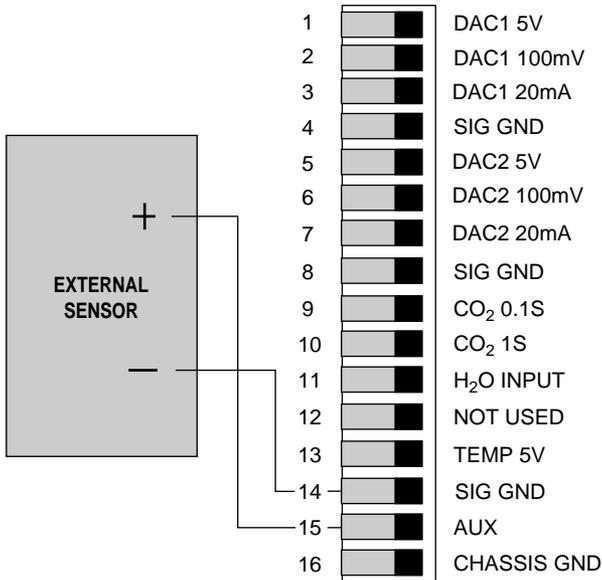


Figure 7-4. Connection of an external sensor for analog signal input.

The calibration equation is of the form  $Y = A + BX + CX^2$ , where A, B, and C are FCTs 71, 72, and 75, and X is the actual mV output of the sensor. See Section 5.3, FCT 70.

## 7.5 Temperature Output

The analyzer temperature can be recorded by connecting a logging device to the terminal strip on the analyzer back panel. Connect the positive lead from the data logger to the terminal labeled **TEMP 5V**, and the negative lead to the terminal labeled **SIG GND** (Fig. 7-5).

Temperature output is linear, and can be computed according to

$$T(^{\circ}\text{C}) = \left( \frac{50^{\circ}\text{C}}{4096 \text{ mV}} \right) V$$

where V = the analyzer output in millivolts, and 0V = 0 °C.

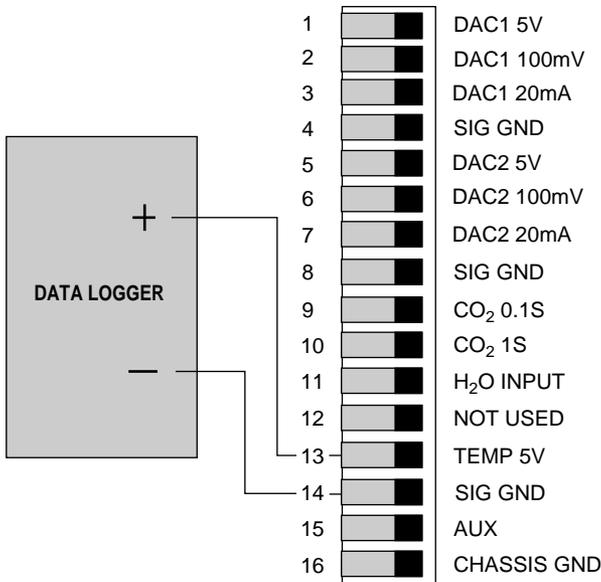


Figure 7-5. Connection of data logger for analyzer temperature output.

## 7.6 Using the 6262-03 Pressure Transducer

The 6262-03 is located inside the LI-6252 case, and senses pressure from a manifold on the optical cell. Because the calibration function used in LI-COR gas analyzers will correct for pressure changes if the pressure in the optical cell is known, the 6262-03 allows for automatic pressure corrections to be performed.

During installation, an adapter board is connected to the analyzer's digital board. The adapter board sends the transducer mV output to the Auxiliary Input (terminal #15) on the terminal strip (Figure 7-6). Because the mV *output* of the transducer is connected to the Auxiliary Input on the terminal strip, the signal can be measured by connecting a voltmeter or datalogger to the **Aux Input** and **Sig Gnd** terminals. Pressure can then be calculated in externally, if desired. Internal computations are performed provided FCTs 71, 72, 73, and 75 are set correctly (see *Software Considerations* below).

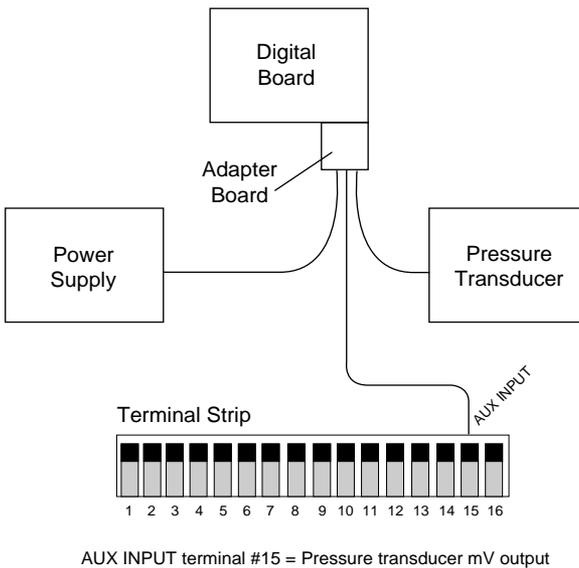


Figure 7-6. Block diagram of electrical connections.

### Software Considerations

The pressure value (kPa) used in the calculation of CO<sub>2</sub> is stored at channel code 43. Pressure can be entered as a constant at FCT 77, or it can be

## Section 7

---

calculated from the 6262-03 mV signal provided to the Aux Input. If you are using the 6262-03, the Auxiliary Destination (FCT 73) *must* be specified as channel **43** (Pressure). Specifying the Auxiliary Destination as channel 43 causes any constant pressure entered in FCT 77 to be ignored.

The response curve for the pressure sensor is given by the equation

$$Y = A + BX + CX^2$$

where Y is the sensor output (in kPa), X is the mV output of the sensor, A is the Y-axis intercept, and B is the calibration multiplier, which is equal to the slope of the line representing the sensor's response (Figure 7-7). On the 6262-03 calibration sheet the offset A is given as FCT 71, and the multiplier B is given as FCT 72. Enter these values into the software at FCT 71 (Aux A) and FCT 72 (Aux B). Make sure that FCT 75 (Aux C) is set to zero. These values convert the mV output of the pressure transducer to pressure in units of kPa.

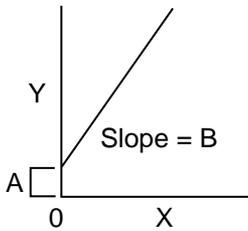


Figure 7-7. Response curve for pressure sensor.

### **Example:**

On the 6262-03 calibration sheet the values listed are as follows:

FCT 71 = 58.239  
FCT 72 = 0.01510  
FCT 73 = 43  
FCT 75 = 0

Enter the above values into software:

FCT 71     

Aux A =	0.0
NEW =	58.239

FCT 72     

Aux B =	0.0
NEW =	0.01510

FCT 73     

Aux Dest	0.0
NEW =	43

FCT 75     

Aux C =	0.0
NEW =	0

You can view the pressure value at FCT 43, and mV output at FCT 44. Both of these values can be viewed on a custom display, or sent via the RS-232C output to a printer and/or computer terminal.



# 8 Maintenance

## 8.1 Recharging the 6000B and 6200B Batteries

Batteries should be fully recharged as soon as possible after use. *Long term storage in a discharged state can reduce the battery's capacity, especially at high temperatures.*

Battery charging circuitry for the 6000B and 6200B batteries is built into the LI-6252, and requires only that the AC line cord be connected. If you are charging one 6000B battery, it will take 1 1/2 - 2 hours (3 - 4 hours for the 6200B) to recharge the battery to 80-90% of full capacity (with the LI-6252 power switch off). For best results, charge the batteries overnight.

Batteries may also be charged during operation of the LI-6252 with AC power. Charging times will be longer than those given above, however.

At room temperature the 6000B will run the LI-6252 for approximately 3.2 hours and the 6200B will last about 6.4 hours.

**NOTE:** One set of external leads with a 3-pin plug connection is also included in the spare parts kit for installation with a user-supplied battery (10.5 - 16VDC, 1.5 amp maximum).

## Storing the Batteries

*Store the batteries fully charged, and in a cool place, if possible. For long-term storage, charge the batteries overnight every month.*

## 8.2 Opening The LI-6252

Remove the 4 screws on the bottom of the LI-6252 housing that are closest to the ends of the housing, directly opposite the 4 rubber feet. There are 2 screws near each end.

Remove all 8 screws from the top of the housing, and slide the cover off.

### 8.3 Internal Soda Lime/Desiccant

**NOTE:** Internal soda lime/desiccant must be changed annually.

**CAUTION!** The instrument should not be turned on for about 24 hours after changing the internal chemicals. The time needed will depend, of course, on how much CO<sub>2</sub> and/or water vapor gets into the detector housing during the exchange of bottles. Leaving the instrument off is done so that water vapor which may have entered the system during the time the chemicals were exchanged will not condense in the optical path when the Peltier coolers controlling the detector temperature are powered up.

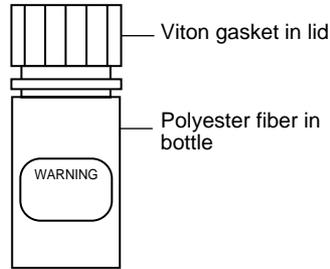
There is a small plastic bottle inside the LI-6252 that contains a mixture of soda lime and anhydrous Mg(ClO<sub>4</sub>)<sub>2</sub> (magnesium perchlorate). This bottle is attached to the CO<sub>2</sub> analyzer's detector housing. Its purpose is to keep the detector free of CO<sub>2</sub> and water vapor, and its dewpoint below -12 °C.

If the CO<sub>2</sub>/H<sub>2</sub>O concentration in the detector rises, the analyzer response curves will change, and the calibration polynomial will no longer match the response curve, and the factory-supplied calibration function will be invalid. If the dewpoint in the detector rises above -12 °C, condensation may form, resulting in a large shift in the zero and/or span. The READY light will also fail to light. **For these reasons, the internal soda lime/desiccant must be changed annually.**

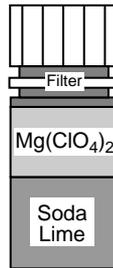
The plastic bottle of soda lime/desiccant is located inside the nickel-plated desiccant bottle cover, which is connected perpendicularly to the detector housing (Figure 8-1). The bottle cover is attached with 2 Allen head screws, which may be removed with the hex key included in the LI-6252 spare parts kit. Be careful not to drop the hex nuts onto the LI-6252 circuit boards, as damage may occur.

Follow these steps to replace the soda lime/desiccant bottle:

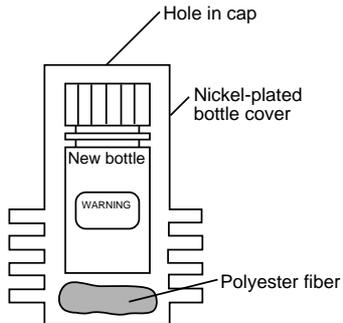
1. The spare soda lime/desiccant bottle (in the spare parts kit) is shipped without chemicals. You will need to procure chemicals locally. When handling chemicals, observe all manufacturer's safety warnings.



2. Fill the bottle slightly more than half full with soda lime. Fill to the neck with magnesium perchlorate. Tap the sides of the bottle to settle the chemicals. Insert a polyester fiber wad (provided), packing firmly. This helps keep dust from escaping. Make sure the filter disc in the lid is intact; replace if necessary.



3. Remove the old bottle; insert the new bottle into the bottle cover bottom first, and reattach the cover to the analyzer. Note that there is a small wad of polyester fiber in the bottom of the nickel-plated bottle cover, to prevent the soda lime/desiccant bottle from rattling.



Magnesium perchlorate is the recommended desiccant since it does not interact with CO<sub>2</sub>. **Do not use any other desiccant.** Several grades of magnesium perchlorate are available from commercial suppliers. In general, the more granular (as opposed to powdery) the grade the better. One type that works well is marketed under the name *Dehydrite*, and is available (catalog number C260-M61) from Thomas Scientific, P.O. Box 99, Swedesboro, NJ 08085-6099. (609) 467-2000. See List of Suppliers, Appendix B.

**Caution!** Magnesium perchlorate is a strong oxidizing agent. Contact with skin or mucus membranes may cause irritation. Avoid bringing it into contact with acids and organic substances such as cotton, rubber, grain dust, etc. Consult the container label.

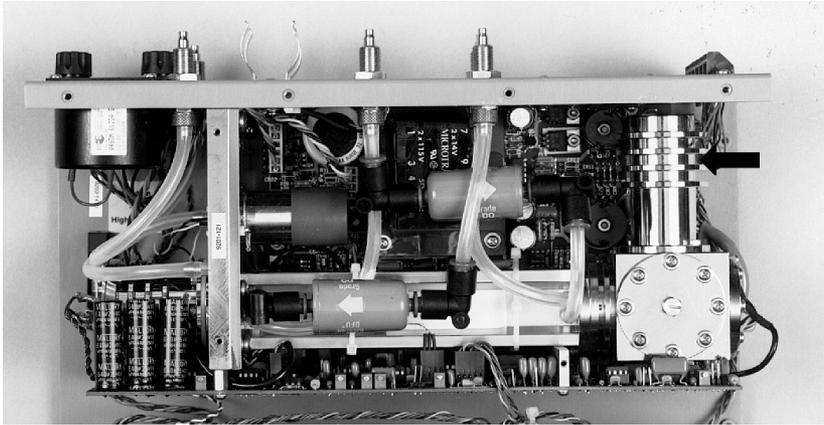


Figure 8-1. Location of internal soda lime/desiccant.

### 8.4 External Soda Lime

The frequency with which you must replace the external soda lime depends greatly on the mode you choose to operate the analyzer in, and how much  $\text{CO}_2$  it is forced to remove.

In differential mode, with the scrubber tube connected to the chopper ports, the soda lime will need to be changed every six months to one year, depending on usage. Once the scrubber tube removes the initial  $\text{CO}_2$  from the circuit, it will only need to remove the small amounts of  $\text{CO}_2$  resulting from tiny leaks in the system.

In absolute mode, the soda lime will degrade more rapidly, since it is purging CO<sub>2</sub> from the reference cell continuously. In this mode, the soda lime may need to be replaced every 1-4 weeks.

To refill the soda lime tube, pack completely full and place a small wad of cotton or polyester wool in one end to keep the pellets from shaking. Make sure that the filter paper discs on either end cap are not clogged (reduces flow rate) or torn. Adhesive-ringed replacement discs are included in the spare parts kit (LI-COR part # 9960-040).

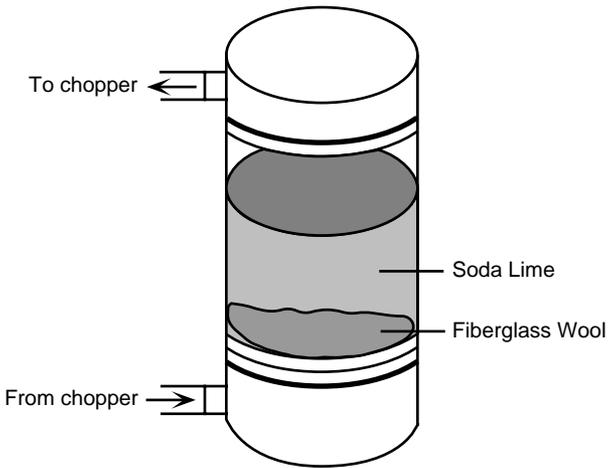


Figure 8-2. External soda lime tube assembly.

### 8.5 Internal Air Filters

The frequency with which the filters need to be replaced will depend upon the operating environment.

The filter on the "SAMPLE IN" inlet will generally need replacement after 1 to 6 months and the filter on the "REFERENCE IN" inlet will need replacement after 6 months to 1 year.

Before installing a new filter, blow clean dry air through it to get out any fibers or other debris that may be loose inside. If any of this material gets into the sample or reference cell, there will be a very large zero shift. Install the filters as shown in Figure 8-3.

Spare filters can be ordered from LI-COR under part number 300-01961 (1 each).

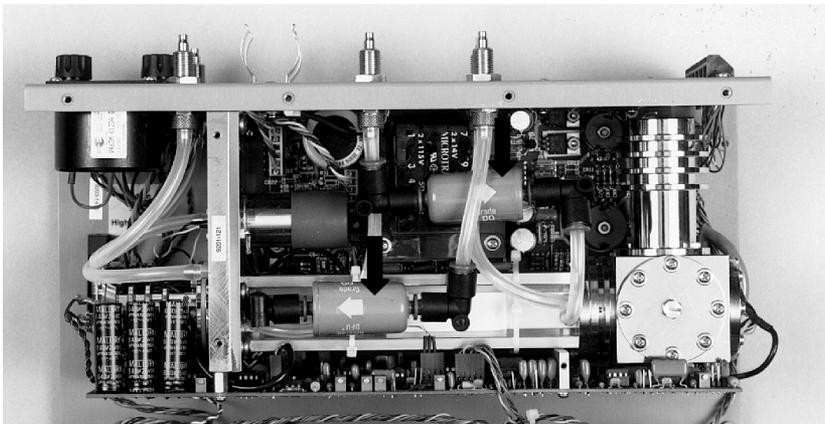


Figure 8-3. New air filters should be installed with the directional arrows in the same orientation as the photo.

## 8.6 Fan Filter

The external fan filter should be cleaned (rinsed out) or replaced as needed. The filter sits in a recessed cavity in the instrument case and can easily be pulled out with your fingers. Two additional external air filters are included in your spare parts kit (LI-COR part # 6560-159).

## 8.7 Fuses

There are two fuse holders on the back panel. The 1/2 amp slow blow fuse is for 110 VAC line voltage and the 1/4 amp slow blow fuse is for 220 VAC line voltage. The 2 amp fast blow fuse is for the external batteries. If the LI-6262 fails to turn on, check the fuse for the power source you are using (battery or AC). If the analyzer continually blows fuses it is in need of repair.

<p><b>NOTE:</b> At 50 Hz, 220 VAC, it may be necessary to use the 1/2 amp slow blow fuse due to near saturation of the power transformer core.</p>
--



# 9

## Troubleshooting

This section summarizes some things that might go wrong, and suggests what to do about these problems should they happen.

### Power ON Problems

- **Nothing happens .**

Try another battery. If using AC power, check the AC voltage switch on the back panel to make sure that it is set properly. Check the fuses to see if one has blown.

- **Display flickers, then goes out .**

The analyzer is probably shutting down because the battery voltage is too low (<10.5 V). Try another battery.

### Ready Light Won't Illuminate.

The ready light may fail to illuminate for a number of reasons; some of these problems you can fix yourself.

- Ambient temperature is greater than about 55 °C.
- CO<sub>2</sub> level in the reference cell is greater than about 3000 ppm.
- CO<sub>2</sub> or water vapor in the detector, caused by internal soda lime/desiccant bottle leaking or if the internal soda lime/desiccant has been exhausted.
- Span potentiometer has an open circuit.

### **Zero and/or Span Adjustments Difficult to Set.**

If the zero and/or span adjustments are difficult to set, check to see that the analyzer is configured correctly (jumper tubes, soda lime, etc.).

Make sure external soda lime is fresh. Check for leaks on soda lime tube (caps on tight). Check for internal leakage as follows:

Configure the analyzer for absolute mode measurement. Flow CO<sub>2</sub>-free air through the sample cell, and breath into the cool-air intake filter (just below the RS-232C port) at the back of the analyzer. The displayed CO<sub>2</sub> should not rise by more than a few ppm. A sharp rise in the displayed CO<sub>2</sub> coinciding with your breathing indicates a leak. A slow increase of 2 to 3 ppm (depending on the flow rate of air through the sample cell) can be expected due to diffusion of CO<sub>2</sub> through the Bev-a-line tubing and does not indicate a leak.

### **Analyzer Displays CO<sub>2</sub> and/or AUX Instead of Values.**

This indicates an overrange condition of the CO<sub>2</sub> and/or auxiliary inputs.

### **Analyzer Displays Zero for CO<sub>2</sub> Values.**

- Check the calibration list (FCT 01).
- Check pressure (FCT 43). If FCT 73 is set to 43, then pressure is computed from FCTS 71, 72, and 44; otherwise, it comes from FCT 77.



## Specifications

**Type:** Differential, non-dispersive infrared gas analyzer. Functions in differential or absolute mode.

**Calibration:** Factory linearization over 0-3000 ppm range using NIST-traceable standard gases.

**Temperature Range:** 0-50 °C ambient, 0-52 °C optical bench temperature.

**Sensor:** Solid state detector, filtered for detection at 4.26 microns. No sensitivity to motion.

**Chopping Frequency:** 500 hertz.

**Source Life:** >10,000 hours.

**Response Time:** Software selectable at 1 to 30 seconds to 99% of reading. 0.1 second response time is possible with a factory modification.

**Noise Level (ppm, peak-to-peak):** Typical: 0.2 ppm, Maximum: 0.4 ppm

**Short Term Repeatability:** ± 0.2 ppm at 350 ppm.

**Optical Bench:** Sample cell size: 0.6 H × 1.3 D × 15.2 cm L(0.25" × 0.5" × 6.0"). Volume: 11.9 cm<sup>3</sup>.

**Warm-up Time:** 5 minutes.

**Zero Drift** (over time):

First Hour: <5 ppm at 25 °C.

After first hour: <1 ppm per hour at 25 °C.

**Zero Drift** (with temperature): 0.12 ppm/°C typical, 0.45 ppm/°C maximum.

**Span Drift:** Typically <1 ppm in 24 hours at 25°C and 350 ppm (absolute mode).

**Accuracy:** ± 1 ppm at 350 ppm (<3 ppm maximum). ± 2 ppm at 1000 ppm (<6 ppm maximum).

**Gas Temperature:** Measured by a thermistor. Accuracy: ± 0.5°C, 0-60 °C. Resolution: 0.03 °C.

**Gas Pressure:** Maximum allowable pressure is 17 kPa.

**Maximum Flow through Analyzer:** 10 liters/minute.

**Water Sensitivity:** Typical sensitivity of the analyzer for dry to saturated air at 25 °C is <2 ppm at 0 ppm concentration. Water sensitivity can be removed by measuring the water vapor concentration and using the LI-6252's software to correct for band broadening due to water vapor.

### **Back panel connections (CO<sub>2</sub>):**

**Analog:** Two channels, each having 100 mV, 5V, and 20mA full scale, 12 bit D/A; the full range reading can be scaled within these output ranges (e.g. a full range of 350 ppm over 100 mV full scale).

**RS-232C:** Software selectable parameters (baud rates up to 9600, stop bits, parity, check XON/XOFF).

**Non-linear:** 0-7500 mV for 0 to 3000 ppm, typical.  
± 15,000 mV maximum.

**Auxiliary Input/Output Channel:** 0-4096 mV.

**Display:** 2 line by 16 character backlit LCD with enlarged characters.

**Hose Connections:** Rapid connect hose fittings for 4 mm ID × 6 mm OD diameter plastic tubing.

**Temperature Range:** 0-50 °C ambient, 0-50 °C optical bench temperature.

**Resolution:** High resolution and sensitivity provided via 16-bit analog-to-digital converter and user selectable signal averaging time (up to 30 seconds, set in 1 second increments).

**Software Features:** Setup of parameters, scaling of analog outputs, signal averaging time, selection of RS-232C output parameters, selection of automatic output of data, external control of software via the RS-232C port.

**Program Memory:** 32K ROM. System parameters (user entered) stored in EEPROM. 8K bytes RAM.

**Keypad:** 16 key keypad for selecting software functions and entering numbers.

**Power Requirements:** 100-130 VAC or 200-260 VAC (47-65 hertz), or 10.5 - 16 VDC, 1.5 amp maximum.

**Power Consumption:** 8-12 Watts DC (dependent on temperature).

**6000B Rechargeable Battery.** Provides 2 hours of battery life.

**6200B Rechargeable Battery.** Provides 4 hours of battery life.

**Recharging Time:** 3 hours for 6000B or 6 hours for 6200B.

**Size:** 33.5 L × 13 W × 24 cm D (13" × 5" × 9.5").

**Weight:** 3.5 kg (7.7 lb).

## **6262-03 Pressure Transducer Specifications**

**Pressure Range:** 0 to 115 kPa absolute.

**Accuracy (with software correction):** ± 0.1% full scale.

**Resolution:** 0.002 kPa.

**Signal noise (peak-to-peak):** 0.002 kPa typical.

**Power consumption:** 50 mA (steady state).

**Weight:** 0.88 oz. (25 g).



# B Suppliers

---

The company names, addresses, and phone numbers are the most current we have at the time of this printing. In some cases the information may change without notice.

## **Soda Lime (6-12 mesh) and Magnesium Perchlorate (Anhydrous) $Mg(ClO_4)_2$**

### **GFS Chemicals**

P.O. Box 245

Powell, OH 43065

Phone: 614-881-5501

FAX: 614-881-5989

Toll free: 800-858-9682

**Soda Lime:** Part #66352

**$Mg(ClO_4)_2$ :** Part #49001 (500g,  
<8% water)

### **Fisher Scientific**

711 Forbes Avenue

Pittsburgh, PA 15219-4785

Phone: 201-467-6400

FAX: 201-379-7415

Toll free: 800-776-7000

Toll free FAX: 800-926-1166

**Soda Lime:** Part #S201-212  
(LI-COR Part #9960-071)

**$Mg(ClO_4)_2$ :** Part #M54-500 (500g)

**Thomas Scientific**

P.O. Box 99

Swedesboro, NJ 08085-6099

Phone: 609-467-2000

FAX: 609-467-3087

Toll free: 800-345-2100

Toll free FAX: 800-345-5232

**Soda Lime:** Part #C703-B76

**Mg(ClO<sub>4</sub>)<sub>2</sub>:** Part #C260-M61  
(Dehydrite, 500g)



# C Software Commands

Function Code	Description	Page
00	**SETUP**	5-3
01	Set CO <sub>2</sub> Calibration	5-4
02	Set H <sub>2</sub> O Calibration	5-5
03	Set Miscellaneous	5-5
04	Set Displays	5-6
05	Set D/A Conversion #1	5-7
06	Set D/A Conversion #2	5-7
07	Backlight ON/OFF	5-8
08	Test Menu	5-8
09	Integrate	5-11
10	**PRINT**	5-13
11	Print Header	5-14
12	Print Data	5-14
13	Set Print List	5-14
14	Auto Print	5-15
15	Auto Header	5-15
16	Print Calibration Data	5-16
17	Set RS-232C Port	5-17
18	Reset Timer	5-18
19	Full Status	5-18
20	**CO <sub>2</sub> **	5-20
21	CO <sub>2</sub> raw mV	5-20
22	CO <sub>2</sub> μmol/mol absolute	5-20
23	CO <sub>2</sub> μmol/mol differential	5-20
24	CO <sub>2</sub> Pa absolute	5-20
25	CO <sub>2</sub> Pa differential	5-20
26	CO <sub>2</sub> μg/g absolute	5-20
27	CO <sub>2</sub> μg/g differential	5-20
29	CO <sub>2</sub> μmol/mol reference	5-20
30	**H <sub>2</sub> O**	5-20

Function Code	Description	Page
40	**MISCELLANEOUS**	5-21
41	Temperature mV	5-21
42	Temperature °C	5-21
43	Pressure kPa	5-21
44	Auxiliary mV	5-21
45	Timer	5-21
46	Integration A	5-22
47	Integration peak value	5-22
49	Software Revision ID	5-22
50	**CO <sub>2</sub> CALIBRATION**	5-23
51	CO <sub>2</sub> Calibration T	5-23
52	CO <sub>2</sub> Calibration K	5-23
53	CO <sub>2</sub> Calibration A	5-23
54	CO <sub>2</sub> Calibration B	5-23
55	CO <sub>2</sub> Calibration C	5-23
56	CO <sub>2</sub> Calibration D	5-23
57	CO <sub>2</sub> Calibration E	5-23
59	CO <sub>2</sub> Reference μmol/mol	5-23
60	**H <sub>2</sub> O CALIBRATION**	5-23
70	**MISCELLANEOUS**	5-24
71	Auxiliary A (Offset)	5-24
72	Auxiliary B	5-25
73	Auxiliary Destination	5-25
74	Average Time	5-26
75	Auxiliary C	5-25
76	Vapor Flag	5-27
77	Pressure	5-28
78	Vapor Correction a	5-28
80	**DAC**	5-29
81	D/A Conversion Code #1	5-31
82	D/A Conversion Code #1 Min.	5-31
83	D/A Conversion Code #1 Max.	5-31
84	D/A Conversion Code #2	5-32
85	D/A Conversion Code #2 Min.	5-32
86	D/A Conversion Code #2 Max.	5-32
90	**DISPLAYS**	5-33
91-99	Displays 1-9	5-33



# D Channel Code Headers

The following table shows the way in which channel code headers will appear when sent from the LI-6252 to a terminal or printer through the RS-232C port.

Header	Description	Channel Code
C2 mV	CO <sub>2</sub> raw mV	21
C2 μm/m	CO <sub>2</sub> μmol/mol absolute	22
ΔC2μm/m	CO <sub>2</sub> μmol/mol differential	23
C2 Pa	CO <sub>2</sub> Pa absolute	24
ΔC2 Pa	CO <sub>2</sub> Pa differential	25
C2 μg/g	CO <sub>2</sub> μg/g absolute	26
ΔC2μg/g	CO <sub>2</sub> μg/g differential	27
REFμm/m	CO <sub>2</sub> reference (μmol/mol)	29
H2 mV	H <sub>2</sub> O raw mV	31
H2 mm/m	H <sub>2</sub> O mmol/mol absolute	32
ΔH2mm/m	H <sub>2</sub> O mmol/mol differential	33
H2 kPa	H <sub>2</sub> O kPa absolute	34
ΔH2 kPa	H <sub>2</sub> O kPa differential	35
H2 mg/g	H <sub>2</sub> O mg/g absolute	36
ΔH2mg/g	H <sub>2</sub> O mg/g differential	37
DewPt C	H <sub>2</sub> O Dewpoint °C	38
REFmm/m	H <sub>2</sub> O reference (mmol/mol)	39
Temp mV	Temperature mV	41
Temp C	Temperature °C	42
P(kPa)	Pressure (kPa)	43
Aux mV	Auxiliary mV	44
Timer	Timer (s)	45



# Console Commands

<b>Setup Commands</b>	
00 **SETUP**	10 **PRINT**
01 Set CO <sub>2</sub> Calibration	11 Print Header
02 Set H <sub>2</sub> O Calibration	12 Print Data
03 Set Miscellaneous	13 Set Print List
04 Set Displays	14 Auto Print
05 Set D/A Conversion #1	15 Auto Header
06 Set D/A Conversion #2	16 Print Calibration Data
07 Backlight ON/OFF	17 Set RS-232C Port
08 Test Menu	18 Reset Timer
09 Integrate	19 Full Status

<b>Channel Codes</b>		
20 **CO <sub>2</sub> **	30 **H <sub>2</sub> O**	40 **MISC**
21 CO <sub>2</sub> raw mV	31 H <sub>2</sub> O raw mV	41 Temperature mV
22 CO <sub>2</sub> μmol/mol abs.	32 H <sub>2</sub> O mmol/mol abs.	42 Temperature °C
23 CO <sub>2</sub> μmol/mol diff.	33 H <sub>2</sub> O mmol/mol diff.	43 Pressure kPa
24 CO <sub>2</sub> Pa abs.	34 H <sub>2</sub> O kPa abs.	44 Auxiliary mV
25 CO <sub>2</sub> Pa diff.	35 H <sub>2</sub> O kPa diff.	45 Timer
26 CO <sub>2</sub> μg/g abs.	36 H <sub>2</sub> O mg/g abs.	46 Integration A
27 CO <sub>2</sub> μg/g diff.	37 H <sub>2</sub> O mg/g diff.	47 Integration peak value
29 CO <sub>2</sub> μmol/mol ref.	38 H <sub>2</sub> O Dewpoint	49 Software Revision ID
	39 H <sub>2</sub> O mmol/mol ref.	

### Calibration and Configuration Stacks

<p>50 <b>**CO2 CAL**</b>                      51 CO<sub>2</sub> Calibration T                      52 CO<sub>2</sub> Calibration K                      53 CO<sub>2</sub> Calibration A                      54 CO<sub>2</sub> Calibration B                      55 CO<sub>2</sub> Calibration C                      56 CO<sub>2</sub> Calibration D                      57 CO<sub>2</sub> Calibration E                      59 CO<sub>2</sub>reference μmol/mol</p>	<p>60 <b>**H2O CAL**</b>                      61 H<sub>2</sub>O Calibration T                      62 H<sub>2</sub>O Calibration K                      63 H<sub>2</sub>O Calibration A                      64 H<sub>2</sub>O Calibration B                      65 H<sub>2</sub>O Calibration C                      68 H<sub>2</sub>O reference mmol/mol</p>
--	---

### Calibration and Configuration Stacks

<p>70 <b>**MISC**</b>                      71 Auxiliary Offset                      72 Auxiliary Multiplier                      73 Auxiliary Destination                      74 Average Time                      75 Auxiliary C                      76 Vapor Flag                      77 Pressure                      78 Vapor Correction a</p>	<p>80 <b>**DAC**</b>                      81 D/A Conv. Code #1                      82 D/A Conv. #1 Min.                      83 D/A Conv. #1 Max.                      84 D/A Conv. Code #2                      85 D/A Conve. #2 Min.                      86 D/A Conv. #2 Max.</p>	<p>90 <b>**DISP**</b>                      91 Display 1                      92 Display 2                      93 Display 3                      94 Display 4                      95 Display 5                      96 Display 6                      97 Display 7                      98 Display 8                      99 Display 9</p>
---	---	---

## Remote Commands

Function	Type the following on a computer or terminal (comments).
01 Set CO <sub>2</sub> Calibration	<b>*01T,K,A,B,C,D,E,REF,VAPOR FLAG</b>
02 Set H <sub>2</sub> O Calibration	<b>*02T,K,A,B,C,REF</b>
05 Set D/A Conversion Code #1	<b>*05x,low,high</b> (x is channel code 22-27, 32-38, 42)
06 Set D/A Conversion Code #2	<b>*06x,low,high</b> (same as 05)
07 Backlight	<b>*07Y</b> (Yes) or <b>*07N</b> (No) to turn backlight ON/OFF)
09 Integrate	<b>*09x,start,[start value],stop, [stop value]</b> (x is channel code 22-29, 32-39)
11 Print Header	<b>*11</b> (prints header)
12 Print Data	<b>*12</b> (prints data)
13 Set Print List	<b>*13x,x,x,x,x,x,x,x,x,x,x</b> (x is any channel code 21-29, 31-39, 41-47)
14 Auto Print	<b>*14x</b> (prints a line of data every x seconds where x is any number 0.2, 0.5, or 1 to 3600)
15 Auto Header	<b>*15x</b> (prints a column header every x lines of data, from 1 to 999)
16 Print Calibration Data	<b>*16</b> (prints calibration stack for H <sub>2</sub> O & CO <sub>2</sub> )
18 Reset Timer	<b>*18</b> (resets the timer to zero)
19 Full Status	<b>*19x</b> (x is optional parameter to output)
46 Integration A	<b>*46</b>
47 Integration Peak Value	<b>*47</b>
49 Software Revision I.D.	<b>*49</b>
71 Auxiliary A	<b>*71&lt;A&gt;</b> (A is the auxiliary A value)
72 Auxiliary B	<b>*72&lt;B&gt;</b> (B is the auxiliary B value)
73 Auxiliary Destination	<b>*73x</b> (x is auxiliary destination channel <null>, 29, 39, or 43)
74 Set Average Time	<b>*74x</b> (x is any value from 0 to 30)
75 Auxiliary C	<b>*75&lt;C&gt;</b> (C is auxiliary C value)
76 Vapor Flag	<b>*76x</b> (x is 0, 1, or 2 to turn ON/OFF vapor/dilution corrections)
77 Pressure	<b>*77x</b> (x is barometric pressure in kPa)
78 H <sub>2</sub> O Cal. a	<b>*78x</b> (x is vapor correction a)
91 Display 1 	<b>*91x,x</b> (x is channel code 21-27, 29, 31-39, 41-44, for top and bottom line)
99 Display 9	<b>(*91 - *99</b> are all the same)



# F

## Connector Descriptions

---

### 25 Pin RS-232C DCE Port

<u>Pin #</u>	<u>Name</u>
1	Frame ground
2	Received data
3	Transmitted data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground
8	Carrier Detect
9-19	Not connected
20	Data Terminal Ready
21-25	Not connected

### 1000-04 DTE To DCE Cable

The 1000-04 cable included is a pin-for-pin connection between the 25-pin connectors on either end. The 1000-04 is terminated with male connectors on both ends; a female-to-female gender changer may be required to connect the LI-6252 to some computers and/or printers.



## Sample Program

The following is a sample Borland's C program that could be used to calculate CO<sub>2</sub> and/or H<sub>2</sub>O concentrations. The CO<sub>2</sub> calculations use the water correction equations described in Section 6.

```
/*  
  
gascomp.c - Implements LI-COR IRGA equations  
  
*/  
  
#include <stdio.h>  
#include <math.h>  
  
static double ppm(double mV, double Cr, double Tirga, double vp_r, double vp_s, double kPa);  
static double cal(double mv);  
static double temp_correction(double t);  
static double inverse_cal(double cppm);  
static double cal_slope(double mv);  
static double chi(double mfw);  
static double p0_over_p(double kPa);  
  
static double T_cal, K_cal, A_cal, B_cal, C_cal, D_cal, E_cal, Water_A;  
static int water_flag;  
  
/* ----- */  
  
static double ppm(double mV, double Cr, double Tirga, double vp_r, double vp_s, double kPa)  
{  
    /* This function implements Equations 6-6 (LI-6251 manual), Equations 6-13 (LI-6252 manual)  
       or Equations 3-29 (LI-6262 manual).  
  
    mV - co2 signal in mV  
    Cr - reference concentration (ppm)  
    Tirga - Gas temp (C)
```

vp\_r - reference cell vapor pressure (kPa)  
vp\_s - sample cell vapor pressure (kPa)  
kPa - total pressure (kPa)

\*/

double Vref, gain, chi\_ws, chi\_wr, eff\_cr, tc, eff\_mv, result, inv\_cal;

tc = temp\_correction(Tirga);

if (Cr == 0.0) {

/\* absolute mode

\*/

chi\_ws = chi(vp\_s/kPa);

eff\_mv = mV/chi\_ws\*p0\_over\_p(kPa);

result = chi\_ws \* cal(eff\_mv) \* tc;

return result;

}

/\* differential mode

\*/

chi\_wr = chi(vp\_r/kPa);

eff\_cr = Cr / temp\_correction(Tirga) / chi\_wr;

inv\_cal = inverse\_cal(eff\_cr);

Vref = chi\_wr \* inv\_cal / p0\_over\_p(kPa);

gain = (1.0 - Vref/K\_cal);

return ppm(Vref + mV\*gain, 0, Tirga, 0, vp\_s, kPa);

}

/\* ----- \*/

static double cal(double mv)

{

/\* The basic irga cal equation - polynomial

\*/

double rtn;

rtn = (A\_cal + (B\_cal + (C\_cal + (D\_cal + E\_cal\*mv)\*mv)\*mv)\*mv)\*mv;

return rtn;

}

/\* ----- \*/

```

static double temp_correction(double t)
{
    return (t + 273)/(T_cal + 273);
}

/* ----- */

static double inverse_cal(double cppm)
{
    /* returns the mV that would be generated if in absolute mode with
    cppm in the sample cell
    */
    double mv_old = 0, mv, c;

    /* crude first guess
    */
    if (water_flag)
        mv = cppm/75 * 5000;
    else
        mv = cppm/3000 * 5000;

    while (fabs(mv - mv_old) > 0.5) {
        mv_old = mv;
        c = cal(mv_old);
        mv = mv_old - (c - cppm) / (cal_slope(mv_old));
    }
    return mv;
}

/* ----- */

static double cal_slope(double mv)
{
    /* returns the slope of the cal function
    */
    return A_cal + (2*B_cal + (3*C_cal + (4*D_cal + 5*E_cal*mv)*mv)*mv)*mv;
}

/* ----- */

static double chi(double mfw)
{

```

```

/* Eqn 3-21 (LI-6262 manual) or 6-5 (LI-6251 or LI-6252 manual).
*/
return 1 + (Water_A -1) * mfw;
}

/* ----- */

static double p0_over_p(double kPa)
{
if (water_flag)
/* return (101.3 / kPa) * 0.88451 + 0.10889; */ /* The LI-6262 approx. */
return pow(101.3 / kPa, 0.9);
else
return 101.3 / kPa;
}

/* ----- */
/* ----- */

double compute_co2(double Cal_temp, double Cal_k, double coeffs[],
double mv, double temp, double ref, double pressure,
double vap_ref, double vap_samp, double water_corr_a,
int vapor_correct_flag)
{
/*
Compute co2 concentration (umol/mol)
Cal_temp - calibration temp (C)
Cal_k - calibration K factor
coeffs[] - Calibration A, B, C, D, and E
mv - raw CO2 signal (mV)
temp - IRGA temp (C)
ref - Co2 reference concentration (umol/mol)
vap_ref - Vapor concentration (mmol/mol) of reference side
vap_samp - Vapor concentration (umol/mol) of sample side
water_corr_a - A value for water correction
vapor_correct_flag - 0 no vapor corrections
1 band broadening only
2 band broadening, and dilution based on ref

Returns CO2 concentration in umol/mol
*/

double Cs;

```

```

water_flag = 0;
T_cal = Cal_temp;
K_cal = Cal_k;
A_cal = coeffs[0];
B_cal = coeffs[1];
C_cal = coeffs[2];
D_cal = coeffs[3];
E_cal = coeffs[4];
Water_A = water_corr_a;

if (vapor_correct_flag == 0) {
    vap_ref = 0;
    vap_samp = 0;
}

Cs = ppm(mv, ref, temp, vap_ref/1000.0*pressure,
          vap_samp/1000.0*pressure, pressure);

/* The dilution correction is hypothetical. It says what the concentration
   in the sample cell would be if the water vapor concentration there
   were the same as in the reference cell.
*/
if (vapor_correct_flag == 2)
    Cs *= (1.0 - vap_ref/1000.0) / (1.0 - vap_samp/1000.0);

return Cs;
}

/* ----- */

double compute_h2o(double Cal_temp, double Cal_k, double coeffs[],
                  double mv, double temp, double ref, double pressure)
{
    /*
    Compute co2 concentration (umol/mol)
    Cal_temp - calibration temp (C)
    Cal_k    - calibration K factor
    coeffs[] - Calibration A, B, C
    mv      - raw H2O signal (mV)
    temp    - IRGA temp (C)
    ref     - H2O reference concentration (umol/mol)
    */

```

```

Returns water vapor concentration in mmol/mol
*/

double Ws;

water_flag = 1;
T_cal = Cal_temp;
K_cal = Cal_k;
A_cal = coeffs[0];
B_cal = coeffs[1];
C_cal = coeffs[2];
D_cal = 0;
E_cal = 0;

Ws = ppm(mv, ref, temp, 0, 0, pressure);

return Ws;
}

/* ----- */

double dewpoint(double vp_kPa)
{
    double z;

    z = log10(vp_kPa / .61083);
    return 242.62 * z / ( 7.6448 - z);
}

/* ----- */

```

# Warranty

Each LI-COR, inc. instrument is warranted by LI-COR, inc. to be free from defects in material and workmanship; however, LI-COR, inc.'s sole obligation under this warranty shall be to repair or replace any part of the instrument which LI-COR, inc.'s examination discloses to have been defective in material or workmanship without charge and only under the following conditions, which are:

1. The defects are called to the attention of LI-COR, inc. in Lincoln, Nebraska, in writing within one year after the shipping date of the instrument.
2. The instrument has not been maintained, repaired, or altered by anyone who was not approved by LI-COR, inc.
3. The instrument was used in the normal, proper, and ordinary manner and has not been abused, altered, misused, neglected, involved in and accident or damaged by act of God or other casualty.
4. The purchaser, whether it is a DISTRIBUTOR or direct customer of LI-COR or a DISTRIBUTOR'S customer, packs and ships or delivers the instrument to LI-COR, inc. at LI-COR inc.'s factory in Lincoln, Nebraska, U.S.A. within 30 days after LI-COR, inc. has received written notice of the defect. Unless other arrangements have been made in writing, transportation to LI-COR, inc. (by air unless otherwise authorized by LI-COR, inc.) is at customer expense.
5. No-charge repair parts may be sent at LI-COR, inc.'s sole discretion to the purchaser for installation by purchaser.
6. LI-COR, inc.'s liability is limited to repair or replace any part of the instrument without charge if LI-COR, inc.'s examination disclosed that part to have been defective in material or workmanship.

There are no warranties, express or implied, including but not limited to any implied warranty of merchantability of fitness for a particular purpose on underwater cables or on expendables such as batteries and lamps.

Other than the obligation of LI-COR, inc. expressly set forth herein, LI-COR, inc. disclaims all warranties of merchantability or fitness for a particular purpose. The foregoing constitutes LI-COR, inc.'s sole obligation and liability with respect to damages resulting from the use or performance of the instrument and in no event shall LI-COR, inc. or its representatives be liable for damages beyond the price paid for the instrument, or for direct, incidental or consequential damages.

The laws of some locations may not allow the exclusion or limitation on implied warranties or on incidental or consequential damages, so the limitations herein may not apply directly. This warranty gives you specific legal rights, and you may already have other rights which vary from state to state. All warranties that apply, whether included by this contract or by law, are limited to the time period of this warranty which is a twelve-month period commencing from the date the instrument is shipped to a user who is a customer or eighteen months from the date of shipment to LI-COR, inc.'s authorized distributor, whichever is earlier.

This warranty supersedes all warranties for products purchased prior to June 1, 1984, unless this warranty is later superseded.

DISTRIBUTOR or the DISTRIBUTOR'S customers may ship the instruments directly to LI-COR if they are unable to repair the instrument themselves even though the DISTRIBUTOR has been approved for making such repairs and has agreed with the customer to make such repairs as covered by this limited warranty.

Further information concerning this warranty may be obtained by writing or telephoning Warranty manager at LI-COR, inc.

**IMPORTANT:** Please return the User Registration Card enclosed with your shipment so that we have an accurate record of your address. Thank you.

***LI-COR***®

LI-COR, inc. ● 4421 Superior Street ● P.O. Box 4425 ● Lincoln, Nebraska 68504 USA

Phone: 402-467-3576 ● FAX: 402-467-2819

Toll-free 1-800-447-3576 (U.S. & Canada)

E-mail: [envsales@env.licor.com](mailto:envsales@env.licor.com)

Internet: <http://www.licor.com>